THE ENGINEERING RECORD
PUBLISHED WEEKLY BY THE
McGraw Publishing Company

MAIN OFFICES:
114 LIBERTY STREET, NEW YORK.

BRANCH OFFICES:
PHILADELPHIA: Real Estate Trust Bldg.
CHICAGO: 1140 Monadnock Block.
CLEVELAND: Cuyahoga Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.

United States, Canada, Cuba and Mexico....$3.00 a year.
Foreign subscription .... 6.00 a year.
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD by 10 A. M. Monday of the week of issue. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

REMITTANCES.—Remittances should be made by check, New York draft, or money order, in favor of THE ENGINEERING RECORD.

CHANGES OF ADDRESS.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

BACK COPIES.—No copies are kept on sale beyond fifteen months from date of issue, except in bound volumes.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1906, by the McGraw Publishing Co.

Of this issue of THE ENGINEERING RECORD 12,500 *copies are printed. Total circulation for* 1906 *to date* 307,500 *copies, an average of* 12,813 *copies per week.*

TABLE OF LEADING ARTICLES.

Concrete-Steel Columns and Connections......... 725
Electrolysis in Power Stations..................... 725
The Vauxhall Bridge at London..................... 726
Public Improvements in Small Cities............. 727
The Cross River Dam in the Croton Water Shed. (Illustrated) 728
A Thirty-Three Track Bridge at Chicago. (Illustrated) 731
The Present Status of the Steam Turbine.......... 732
Reinforced Concrete Sewer at South Bend. (Illustrated) 736
The Structural, Mechanical and Sanitary Aspects of the Central Californian Catastrophe—III. (Illustrated) 737
Steel Wharves at Manila. (Illustrated) 741
A British Investigation of Reinforced Concrete...... 742
Short-Span Bridges on the Baltimore & Ohio Railroad. (Illustrated) 744
The Formation of Rings in Cement Kilns.......... 745
Reclamation of Grant Park, Chicago. (Illustrated). 746
Handling Spoil from City Tunnel Workings. (Illustrated) 749
Comparison of Heating and Ventilating Plants Installed in Chicago Public Buildings at Various Periods 750
Book Notes................................. 751
The Cost of Engineering Works.................. 752
Vacation Practice................................. 752

Concrete-Steel Columns and Connections

There are two features of concrete-steel construction brought out in the letter from Mr. F. F. Weld printed in this journal a fortnight ago which are of so much importance to this class of structural work that they merit comment at this time. One of these features covers the treatment of shearing at the connections between the ends of beams and girders and columns or posts, which receives less consideration by Mr. Weld than the other, i. e., the joint action of concrete and steel in a column in which the steel is a self-sustaining column in itself. Both these topics are of the utmost importance in concrete-steel construction; and it is not too much to say that failure to give them proper consideration has been the cause of some failures and the discrediting of the concrete-steel combination in quarters where its standing should not be made to suffer in consequence of bad design.

There has been such a desire to attain economy on the part of some designers that they have passed that mark and attained cheapness. Economic construction is highly desirable, but cheap construction may be an entirely different matter, as it usually is. The cheapening of concrete-steel columns has been carried too far in certain directions. The use of round steel rods having no sensible carrying capacity in themselves as columns as a reinforcement of concrete columns is a questionable procedure. The disrupting tendency exerted on the concrete by such rods can certainly be counteracted by a suitable amount of banding, but the latter does not remove all uncertainty as to the proper working load upon such columns. On the other hand, if the steel reinforcement takes the shape of a true steel column capable of carrying its share of compressive loading and of such dimensions that the concrete is enclosed in it, there is no disrupting tendency from any source and the steel reinforcement constitutes an ideal agent for holding together the concrete, so as to give it an enhanced bearing capacity. In such a view the concrete enclosed within the outer dimensions of the steel column would be counted as load-carrying concrete. The shell of concrete exterior to the steel work would be for protection against fire only.

There remains still the question which is raised by Mr. Weld and has been raised by other engineers regarding this class of design, viz., the sufficiency of the combined action of steel and concrete in such a reinforced column. At first sight it may appear that the steel will carry more than its share of the column load, but a little reflection will show that the concrete in such a column may be assumed to carry its proper portion of the load precisely as in a reinforced beam or girder. The rivet heads of the steel column reinforcement, the lattice bars, batten plates or other details, all form the most positive bond between steel and concrete that can be imagined as part of the design of such a member. There are numerous composite beams in which the steel reinforcement is simple round or square rods frequently bent to accomplish some purpose of design. Such beams cannot reasonably be criticised when properly designed, and numerous experiments have justified the confidence placed in them. In such members the bond between the concrete surrounding the rods and the rods themselves is less positive than that in the type of reinforced columns under consideration. When, as is frequently the case, the connections of the steelwork between reinforced beams and reinforced columns is such as to extend through the columns these observations receive great additional force. Indeed, it is not conceivable that in this type of reinforced concrete the steel can act to any extent independently of the concrete. The two materials are so disposed and present such interlocking as well as adhesive-shearing surfaces as to compel the most complete joint action, justifying completely the use of a suitable ratio between the moduli of elasticity of steel and concrete in determining the relative unit stresses of the two materials.

The matter of connections between beams or girders and columns needs as scrupulous attention and as careful treatment as any other feature of the entire range of concrete-steel construction. The solidity or stiffness of the entire building depends, perhaps, more on this detail than on the design even of the main members. In the early days of iron and steel construction these connection details were treated with indifference, not so much from intention as from the lack of knowledge as to the part which they were to play in structural stability. At the present time it is a fundamental principle in all good design of structural steelwork, whether in bridges or buildings, to make the connections between columns and beams absolutely strong and rigid. There is no part of the entire structure subjected to more drastic analysis of every detail than that applied to the determination of the number of rivets required as well as the number and size of plates or other pieces involved in this feature of the design. Shearing, tension and compression are all carefully considered and the requisite metal placed in the most advantageous manner possible. This degree of care in the design of corresponding concrete-steel connections has not yet been attained in all cases, but it is absolutely imperative for the best grade of construction. As stated in this journal but a short time ago, the provisions for end shear at columns and for the continuity of beams or girders where such continuity should exist must be positive and of such a character as not to be affected by fine hair cracks in the concrete or by other similar exigencies. The connections of the steel reinforcement should be made with the same degree of efficiency as in all steel work and no pains should be spared to secure enduring continuity of the concrete. The realization of good design in these two important features of this class of construction will ensure the construction of concrete-steel buildings to any practicable height and having a character for strength and stiffness not exceeded even in all-steel frameworks.

Electrolysis in Power Plants.

This journal has been accused in the past of being somewhat biased in its views on the dangerous possibilities of the wandering return currents of electric railways. For this reason it did not feel called upon to draw special attention editorially before this to the rather remarkable statements published on the authority of Messrs. Westinghouse, Church, Kerr & Co., in its issue of April 7, regarding their measures to prevent electrolysis in the condensing equipment of the power plant of the Pennsylvania R. R., at Long Island City. This station is constructed close to the water front and employs salt water for circulation in the surface condensers. Where such a supply is so employed, particularly where it is contaminated by the wastes of a large city, more or less galvanic action takes place at the expense of the condenser tubes. In the case of a railway power station located like this one there was the further probability that the water and the body of the condenser would form a convenient path for return currents; this view was based on observations at important plants elsewhere. At the Long Island station voltmeter readings between the river, the flume and the piping about the building and in the streets indicated a sufficient difference of potential to make trouble, though its polarity was not always the same.

This was probably the first published mention of the danger of electrolysis in power stations, and coming from engineers long identified with electric railways as well as other interests deserves much more attention than it has received. The remedy adopted at this station consists, first, in providing a shunt circuit between the incoming water pipes and the condenser flume, in order to divert as large a proportion of the current from the condensers as possible. This was done by inserting in each water-main connection a short piece of pipe with an insulating joint on each end of it. These short pieces of pipe were then connected to a 750,000 c. m. cable which was carried to the outer end of the condenser intake. This arrangement affords an opportunity for such current as may leak from the pipes to the water contained in them to get back to the river without passing through the piping and condensers. In order to neutralize the effect of such current as may leak past the insulating joints, a small booster generator was provided, its positive pole being connected to the heavy grounded shunt cable and its negative pole to seven points on each condenser, with an adjustable rheostat in each of these branches of the negative circuit. This superimposed voltage can be adjusted by means of the rheostats to counterbalance exactly the natural galvanic electromotive forces due to the brass tubes, the iron shell, the salt circulating water and any stray electromotive forces from outside. With the destructive potentials so counterbalanced, the condenser is in a neutral electric state which is expected to prevent effectively the corrosion and pitting of the condenser tubes and sheets and secure a far longer life than has hitherto been possible for this portion of the steam equipment. A little switchboard panel is placed near each condenser in the engine room basement. The seven rheostats are mounted on it, each connected by an independent negative lead to a different section of each of the three condensers. A differential voltmeter is provided which can be plugged to each of these sections, and its readings enable the rheostats to be adjusted so that the potential is kept at zero. The arrangement of the apparatus is such that it is expected the station operators can keep the condensers absolutely neutral.

Attention is drawn to this system of protection taken by the Pennsylvania R. R. to protect its power station from its own return currents because it is probably the most significant acknowledgement of the insidious dangers of electrolysis yet made by a railway company. When the subject first received general attention about ten years ago, there were very few railway officials who would acknowledge that electrolysis was anything more than a nightmare due to the imperfect assimilation by a few water-works superintendents of ill-assorted scientific data. Later, when the engineers of powerful telephone companies began to complain that the lead sheaths of their cables were being eaten up by railway return currents, the subject received the attention it deserved, although the public statements of railway managers were not altered even then from their former tone of contemptuous joking. Then came the advent of the single-phase system of electric traction, and the assertions concerning the dangers of electrolysis by direct-current operation made by the advocates of the new system have surpassed most of those formerly made by water-works engineers and managers. Now we have one of the most influential engineering companies in the country providing against electrolysis in the power station of the Pennsylvania R. R., which always demands the best engineering methods on all its works, and thus acknowledging by its example a dangerous condition which would have been laughed to scorn by most electric railway officials but a few years ago. Under the circumstances the water-works managers who have fought a long, hard fight for a square deal from the railways which have been destroying their mains have pretty good reason to feel themselves justified by the acts of their opponents.

The Vauxhall Bridge at London.

People who think that progress on the Manhattan bridge over the East River at New York has been at a rate which would allow a snail plenty of opportunity for rest will do well to consider the fact that the Vauxhall bridge over the Thames at London was not opened to the public until last month. After a prolonged controversy over considerations of art which was marked by artist-like personalities, a set of plans were finally adopted which seemed to satisfy the aesthetic critics, the public officials and the tramway interests, the latter previously without a track over any of the Thames bridges. Even after the plans had been definitely adopted the construction proceeded very slowly on account of many requirements which hindered the work. Consequently the final completion of the bridge marks the end of an undertaking which gains interest from other features than the structural design and the manner in which it was executed.

The old Vauxhall bridge was projected just a century ago, when some parishes south of the river petitioned parliament for such a structure. Public expenditure for the purpose did not appeal to parliament, however, particularly as the two districts to be united were of a decidedly rural character. Private parties saw an opportunity to make money out of the structure, and in 1809 they obtained a charter for a bridge of which John Rennie was chief engineer. This was a stone affair, but its cost scared the company after work had begun, and the design was changed to one using iron arches; with this change was a corresponding change in the engineer, James Walker becoming the new technical head. The bridge was opened in 1816, after being three years in building. It was the first iron bridge over the Thames, and was 809 ft. long, 36 ft. wide, and had nine 78½-ft. arches. It cost £175,432, but the expense incurred for the approaches brought the total cost of the work to the company up to £296,998. It was operated as a toll bridge, like several others crossing the river in what is now the County of London, and the tolls caused a great deal of complaint. The House of Commons had the subject investigated by a special committee in 1837, and after thinking over the matter for forty years finally authorized the Metropolitan Board of Works to buy the structure and several others. The purchase price paid for the Vauxhall bridge was £255,000, a pretty good sum for a structure 63 years old, which had been kept in repair mainly by paint.

The construction of a new bridge was urged for three reasons, the small capacity for traffic of the old structure, its hindrance to navigation and the insecurity of the foundations of its piers. Probably little justification existed for the claim that the bridge was crowded unless the old saying, "Two is company, three is a crowd," was considered applicable here. It is not unlikely that a strong desire to run a tramway over the bridge was at the bottom of this claim that the bridge was too narrow, although its worst feature for street car operation was the grades it presented. The assertion that the bridge was an obstacle to river traffic might be of weight if any traffic was impeded, which may be questioned. The condition of the foundations of the piers was such, however, that their strengthening was undoubtedly necessary; in fact, it had been attempted in 1887 by placing bags of cement and depositing slag about them. These measures were unsuccessful in preventing scour and it was accordingly determined by the London County Council that the time was ripe for replacing the bridge.

When the first plans for a new structure were made public there was an immediate outburst of criticism from eminent architects. The Tower bridge had not long before been constructed in defiance of vigorous and prolonged protest from architects, and the feeling aroused then had not subsided when the first designs for the Vauxhall bridge were put on exhibition. The Royal Institute of British Architects finally petitioned the County Council to reject the plans in favor of a monumental masonry structure and this advice was followed. The Council's engineers, however, concluded that a solid granite structure was too costly, so their designs called for three-hinged concrete arches faced with granite. The general features of the design were illustrated in The Engineering Record seven years ago, and to say that they aroused consternation in architectural circles is to state the case mildly. The criticisms of the first design were love pats compared with those on the second, but they were without result until it was found that the foundations under the piers were inadequate for the proposed loads. Accordingly a third plan was prepared, this time for a steel bridge, but the public ridicule of it was so strong that it was never adopted. Finally, in an unofficial way, suggestions were obtained from an eminent architect and a bridge was designed in accordance with them which was satisfactory to the artistic critics. The fight had been a long one, and although they lost in the case of the Tower bridge, they finally won so decisively that a new era in London bridge design was probably inaugurated when the final plans were adopted three years ago.

The details of the bridge are not particularly interesting from an engineering point of view. It consists of a central span of 149 ft. 7 in. with a clearance of 20 ft. above high-water, two intermediate spans of 144 ft. 4¾ in. with clearances of 19 ft., and two shore spans of 130 ft. 5¾ in., with clearances of 14 ft. 11 in. The bridge has a 50-ft. carriage-way and two 15-ft. sidewalks. Each span has thirteen plate ribs, those on the outside being 2¾ ft. deep at the crown and 3 ft. at the ends, and the other 3½ ft. at the crown and 4 ft. at the ends, the outside ribs being made somewhat lighter to allow them to show under the projecting plinth of the parapet. The floor is carried at the center by the ribs and elsewhere by longitudinal girders supported by spandrel posts rising from the ribs. One of the most outspoken critics of the earlier designs, the eminent editor of "The Builder," states that "the low simple railing with plain square balusters; the turned steel balusters at intervals, of very good design, which carry the upper rail; the plain vertical posts on the haunches of the arch—all this is excellent and in the best taste. The masonry bases of the piers are well treated, without any immense mouldings to destroy the scale; above these the piers are faced with riveted steel plating so constructed as to leave sunk panels; these panels are to be occupied by bronze figures on each face, of heroic scale."

These delays due to an artistic protest against the Philistines have been matched by tedious construction. The parliamentary act under which the work was done required the new bridge to be built on the site of the old, without obstructing at one time more than a definite amount of the waterway. Work was begun in 1898 and it was three years before the last of the old piers was removed. One of the abutments and three of the piers were built without much trouble. The second abutment had to be redesigned on account of the poor material for the foundations, while the central pier was the scene of a succession of mishaps which culminated four years ago in the complete collapse of the cofferdam, and caused considerable delay in starting the superstructure.

The history of the bridge is worthy of the consideration of American critics of such work. The record of this structure, which presents no technical features comparable with those of the Blackwell's Island and Manhattan bridges at New York, shows that the task of spanning the East River is not proceeding at an unprecedentedly low rate. The two structures named have been the subject of both artistic and engineering criticism, their erection is far more difficult than that of the Vauxhall bridge, and in addition they have been tied up by taxpayers' suits, so that their slow progress is not surprising, although disappointing. These are the most important ideas suggested by the latest addition to the London bridges.

Public Improvement in Small Cities.

During the last five or six years the resources of the small cities in the whole Mississippi valley have been increasing rapidly. Before that time there was a period when the payment of taxes for the absolute necessities of town existence imposed a considerable strain on the people, but of late this great territory has experienced a succession of good business years which has placed it firmly on its financial feet. As a result of this condition, it is now possible to engage in the construction of much-needed public works, such as the improvement of water plants, the construction of sewerage systems and the paving of streets. Such works of this nature as were formerly constructed in this territory were often rule-of-thumb affairs. It was necessary to economize in every possible direction. Accordingly the water works were built by private companies, the sewers were laid out by the local plumber, and the town surveyor considered himself lucky if he was able to direct even the occasional pieces of pavement which were put down. The consulting engineer was looked upon as a wasteful luxury, good enough for the rich Eastern towns, but out of place where the tax collector had to bite every penny to be sure he was not receiving phony money. It has been apparent of late, however, that this feeling has changed. One town after another has seen its treasury balance mount up, has become reckless, and has engaged a consulting engineer to advise it concerning its public works. As a result it has learned how to make its money go much farther than it ever went before, it has been prevented from engaging in works that were bound to be failures before a stroke was done on their construction, and it has learned that engineering is not a luxury for a wealthy community but rather an absolute necessity for one of small means.

This change in sentiment is most gratifying to those who know what improvements are needed in that section of the country and who have had occasion to be acquainted with the way money has been wasted in the past in ignorant attempts to obtain them. Many times local surveyors and engineers have written to this journal for advice as to the methods to be followed in obtaining the consent of public officials to engage a consulting engineer to assist in preparing plans for sewerage works. These local engineers recognized that their experience was inadequate to keep them from making some blunders, but they could not make their councilmen see the need of such assistance. Such letters have ceased entirely of late, while the reports in the Current News Supplement of this paper have shown a growing tendency to call in specialists for advice on all important undertakings. It is a condition which is eminently satisfactory, not only because it gives the assurance of good plans to communities which have dared to call in a consulting engineer, but also because the practice will afford a precedent to other places.

The people who should be most on their guard against making mistakes are those who will suffer most when they occur. The small towns and cities, which have to be careful in spending each dollar of the public funds, are just those which should secure competent engineering advice before undertaking public works. A fee of five hundred dollars may seem a large sum of money to pay for a few days' work, but if it prevents the useless expenditure of many thousands or enables that expenditure to give much better returns, the fee has been more than repaid. It is the easiest thing in the world to waste a large sum in poor sewers, inadequate water works or worthless street improvements. The trouble is that the fact the money is wasted is not discovered until the construction has been finished and the works put in service. There is no means of knowing, except by calling in an expert, whether the expenditure will be warranted or not, and if a town does not call in such an expert to tell it how the works should be built, it is not likely to do so until long after construction has progressed so far that the damage has been done.

The Engineering Record has often regretted that there was no way of bringing home to the officials of the small cities west of the Alleghenies the importance of retaining engineering specialists to design their large public works. If some plan could be devised for spreading this knowledge in such a way that it would make an impression, the discoverer would deserve recognition as a public benefactor. The design of water works and sewerage systems, the construction of good roads and similar undertakings call for engineering experience which no amount of reading will replace. The reckless way in which smaller communities plunge ahead to waste their money on silly projects would be ludicrous if it were not so unfortunate economically. It is surprising to observe the way in which public officials ignore the main lesson of every successful undertaking, which is intrusting each part of the work to somebody of proved fitness to dispose of it. Any town that has money enough to spend on public works has money enough to engage a consulting engineer to start it on the right path, and if the authorities will direct their energies to selecting a good technical adviser rather than attempting to do his work, the result will be far more satisfactory.

Notes and Comments.

Lead Wool is a material recently used to a considerable extent in Europe for the joints of gas and water mains. It consists of fine threads cut from virgin lead, and is sold in strands about 3 ft. long and weighing about a pound. Yarn is first put in the joint in the usual way but to a greater depth, and then the lead wool is calked in without heating. Each turn of the wool around the pipe must be well calked before the next one is inserted.

The Reinforced Concrete Failure which has been widely reported as occurring at Cape May on May 27 was nothing of the sort. The accident happened in a portion of the new Cape May Hotel about 60 ft. square, consisting of five reinforced concrete floors, which fell into the basement, apparently on account of the failure of the steel columns supporting them. About 60 ft. of the brick front wall fell in, and a corresponding part of the rear wall was so badly damaged that it will have to be reconstructed. Nobody was in the building when the accident occurred, and all information concerning the design of the structure is refused by the parties interested. Engineers who inspected the collapsed structure report, however, that the accident was probably due to overloading the steel columns.

An Electric Furnace has now been in operation for some weeks at the Tacony works of Henry Disston & Sons, making steel of the same grade that is regularly produced by the company's crucible department. It consists of an annular crucible surrounding an iron core and surrounded in turn by an iron casing. When an alternating current is sent through the furnace, the metal in the crucible is speedily melted by the induced current, provision being made for controlling the temperature within narrow limits. The crucible is mounted in such a way that it can be charged, heated and poured without any of the inconveniences attending the handling of crucibles in the usual way. The alternating current used in the experiments has been of 220 volts and the amount used has been at the rate of 640 kw.-hour per ton of steel. It is understood that the experiments have been so successful that they will be continued with a furnace of much larger capacity.

The Trouble in Obtaining Engineers for the Bureau of Yards and Docks of the Navy Department has been mentioned several times in this journal, and it is understood now that the same conditions which render it difficult to bring the personnel of that Bureau up to its full strength are causing trouble in the Reclamation Service. During the last year about forty engineers have resigned and the same number have asked for furloughs, nearly all to join other engineering organizations where the pay is higher and the opportunities for making reputations are greater. The regulations of the Reclamation Service do not permit engineers to accept outside work, even in an advisory capacity, and they are thereby debarred from increasing their income in a way that is permitted, under reasonable restrictions, to most salaried engineers. The Government is also very skimpy in the matter of allowances for traveling and subsistence, and as a result the irrigation engineering organization built up with considerable difficulty and a source of justifiable pride to the Department is in danger of disintegration. There is a certain amount of prestige to be gained in serving the Federal Government in a responsible engineering capacity, but it may be questioned whether this prestige is a sufficient compensation for the smaller financial return and the limited opportunities for personal advancement, as compared with the conditions ruling at present in railway and other companies.

A Serious Water Famine that has been disturbing the people of Cincinnati shows by actual example what may be expected from continued neglect of a great water works plant. Just what particular thing was the active cause of this trouble has not been stated, but it seems to have been a combination of crippled pumping engines and tampering with the system of distribution mains for the different districts. The result, however, was pretty bad, for portions of the city were practically without water for several days, and relief has been obtained only by straining the pumping equipment of the city to its utmost. The primary cause of the trouble is, of course, the fact that the city's water department is not properly managed; whether this is due to the refusal of the city authorities to meet the legitimate requests of the department for supplies and men, or to the incompetence of the people directing the water works affairs is not evident, although reports from several Cincinnati engineers indicate that an equal blend of both causes made up the total reason for the unfortunate conditions. It stands to reason that a city which places the management of its water works under the charge of a watch repairer, as Cincinnati did, is likely to have its water supply troubled. Fortunately for the city, Mr. George H. Benzenberg has been present to give his counsel, which is particularly valuable as he is now the engineering head of the commission building the new water works for the city, and the mayor was also able to persuade Mr. John W. Hill to take immediate charge of the management of the old works and get as much service out of them as possible. What Cincinnati needs permanently in its water department is less politics and more executive ability coupled with technical knowledge.

THE CROSS RIVER DAM IN THE CROTON WATERSHED.

Description of an Unusual Method of Construction Employed on the New York Water-Works.

The Cross River dam now being built to form a reservoir for the storage of about nine billion gallons of water in the Croton watershed, is about one mile from Katonah and 40 miles from the city of New York. It will form a reservoir about three miles long, with an area of about 850 acres and a maximum depth of about 106 ft. It will impound the waters of the Cross River and deliver them to the Croton reservoir through an open channel a few hundred feet long in the original bed of the Cross River. It thus serves as an auxiliary to the new Croton dam and will store water which would otherwise in times of flood be wasted over its spillway.

The construction of this dam and of the Croton Falls dam, about one mile above the head of the new Croton reservoir, was recommended because the storage capacity in the various portions of the Croton watershed was very unequal; a large storage reservoir capacity would make available, except in series of very dry years, water which would otherwise flow over the spillway of the new Croton dam; the two new reservoirs would equalize the storage, and it was possible to complete them and utilize their storage more quickly than the same amount of storage could be utilized at any of the other contemplated reservoir sites. These considerations were of great importance on account of the danger of a shortage in the water supply for the city in dry years. This is so imminent that the construction was considered emergency work and every effort was made to expedite it.

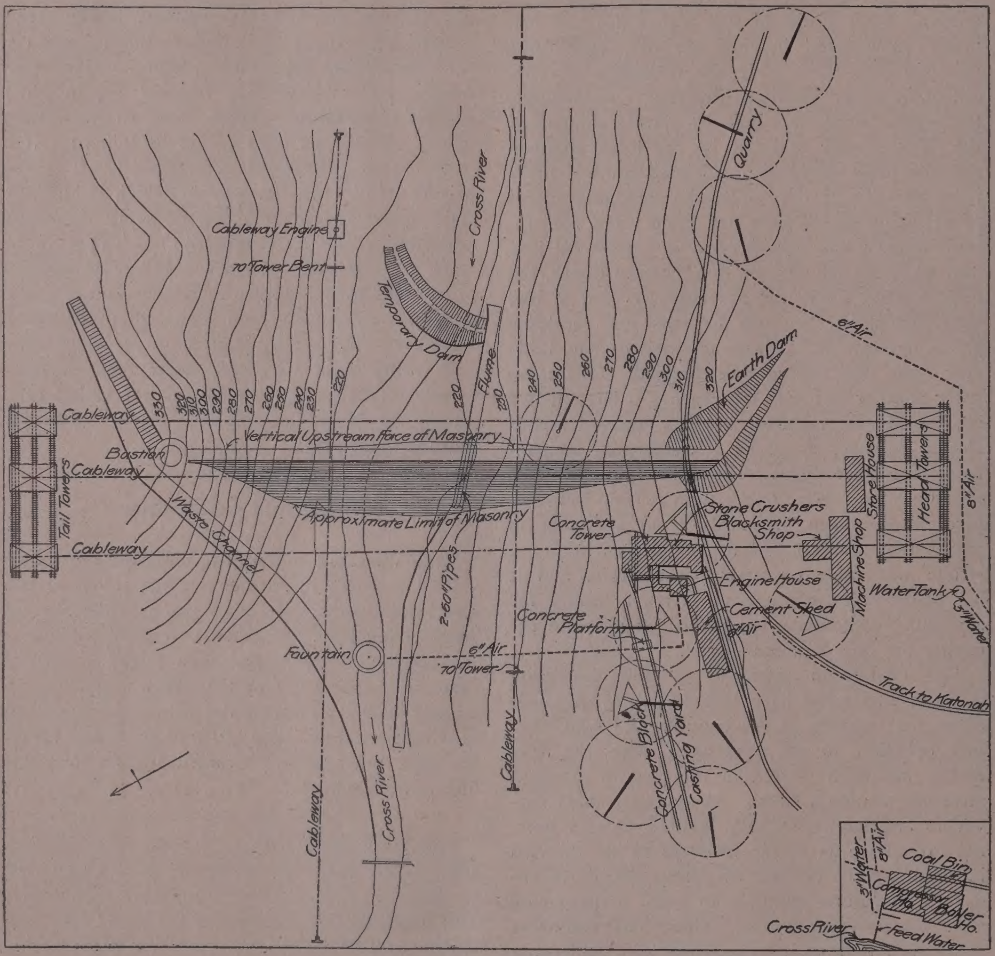
The contract for the dam, reservoir, road building and other works involved was awarded June 23, 1905, to MacArthur Bros. Co. and Winston & Co., who were next to the highest among seven bidders. The contract price compared favorably with the estimate of the chief engineer and the award was made largely in consideration of the emergency character of the work, believing that the contractors who had had recent experience in the construction of a large dam for the Metropolitan water supply of Boston were qualified to do exceptionally rapid work because in addition to this excellent experience they possessed a large amount of available plant that would be immediately installed without waiting for a complete outfit of new machinery to be delivered.

Immediately after the award the contractor commenced the installation of an extensive plant and collected a large force of workmen at the site. In about three months an injunction was granted on a taxpayer's suit, which compelled the contractor to disband his organization of about 550 men and practically discontinue operations in the field. After about two months the injunction was vacated and the contractor resumed active operations, but under a considerable disadvantage, his men having been scattered in every direction. Many of them had secured work in other localities, a large portion having gone South for the winter, so that it was very difficult to restore the efficiency previously obtained, and much more time was lost than the period covered by the injunctions. Operations were continued through the winter and are now in active progress, and it is believed that, notwithstanding the delay and indirect damage resulting from the injunction, it is still possible to finish the work within the stipulated time. This is a consummation anxiously desired by the engineers who recommended the award in special consideration of great expedition, and it is equally of supreme importance to the contractors to finish the work on time and justify the confidence manifested in his experience and reliability.

The axis of the dam is nearly at right angles with the old bed of the Cross River and crosses in a straight line from side to side of the deep, narrow valley. It has a total length of about 900 ft. at the crest and a maximum height of 164 ft. from the lowest point in the foundations to the crest of the dam, the exact figures being dependent upon the excavation which has not yet been entirely completed. The upstream face of the dam is vertical down nearly to the bottom of the reservoir and the downstream face is battered 0.56 to 1. It is 17 ft. wide at the top and about 114 ft. maximum width at the base, as indicated in the general cross-section published in the Engineering Record of May 20, 1905. The foundations are carried to rock, the surface of which is found at a depth varying from 0 to 30 ft. below the original ground level.

The rock found is the ordinary gneiss formation common in this locality and occurs here in thin irregular strata with seams sometimes open and sometimes filled with earth and other materials. The upper portions of the rock are loose and disintegrated, so that it has been found necessary to excavate in it from 5 to 20 ft. to secure a satisfactory surface to receive the foundation. The body of the dam is of cyclopean concrete faced on both upstream and downstream surfaces with large cast blocks of concrete, very little cut stone being used in the structure. The substitution of cast blocks for cut stone results in an estimated saving of over $200,000, and was intended to materially accelerate the progress of the work by eliminating the chances of delay often arising through waiting for stone to be quarried, cut and delivered.

At the south end the dam terminates in an earthern dam with concrete core which is deflected northeast from the line of the main dam. At the north end it terminates in an abutment with a circular bastion 30 ft. in diameter containing a storage chamber 20 ft. in diameter and about 9 ft. in depth. Beyond the bastion the structure is continued with a waste weir deflected east from the line of the dam, and having its crest 10 ft. below that of the main dam. The weir is built of monolithic concrete with a vertical upper face and a lower face battered ½:1. It is reinforced with vertical 1-in. twisted steel rods 5½ ft. apart and has a total length of about 240 ft., adequate to provide for a flow greater than that of the Cross River in heaviest freshets.



Location of Plant when Excavations were Completed.

Water passing over the waste weir is discharged into a spillway channel parallel to it, which is quarried out of the rock. This spillway is nearly parallel to the contours at the upper end, where it slopes about 1.6, and thence extends down the hillside nearly perpendicular to the contours at a slope of about 1.2 for a length of about 300 ft. to its junction with the original bed of the river below the dam. The spillway channel has a width of about 30 ft. at the bottom and side slopes of 1.4. At the lower end it increases in width and is paved at El. 207 where it is built in earth excavation and contains an ornamental fountain with a basin about 15 ft. in diameter. The flow of the water over the weir can be regulated by movable flash boards 2 ft. high. The 31x21¾-ft. gate house is located near the north end of the upstream face of the dam, and is built of cyclopean concrete with plain surfaces. It has outer walls 6 ft. thick and contains two wells with inlets at Els. 224, 259 and 310.

The contract drawings showed a plan for the temporary diversion of the river by means of an earth and rockfill dam built across the valley about 300 ft. above the axis of the permanent dam and another built across it about 900 ft. farther down. Between these two dams the flow of the river is provided for by a wooden flume and steel pipes. The upstream dam is about 200 ft. long and 80 ft. in maximum width, with the crest at El. 230, the elevation of the river bed at this point being about 210. The lower dam is only about 100 ft. long with the crest at El. 212. Both dams were built by a cableway installed for the purpose, and although the upper one raises the water 15 ft. above the original level, it has successfully withstood the freshets during the year since its completion.

The flume is in two sections with an aggregate length of about 575 ft. It is 6½ ft. deep and 16 ft. wide inside, and is made of 2-in. rough planks, mostly sawed by the contractors from timber cut at the site, and is lined with 1-in. tongue and groove boards laid on tar paper and having tarred joints. The floor planks are spiked to 6x10-in. horizontal sills about 5 ft. apart, which project 4 ft. beyond the walls of the flume and are notched to receive the ends of knee-braces engaging the wall posts just above the middle. The upper edges of the walls are tied together with horizontal cap timbers. A cover for the flume has been planned, but it has so far been omitted. The location of the flume is parallel to the old river bed and close to it between the upper dam and the permanent dam.

Where the line of the flume crosses the permanent dam its two sections are united by a pair of riveted steel pipes 60 in. in diameter and about 90 ft. long. They are made of 5/16-in. plates in telescopic sections and are stiffened with 3½x3½-in. outside angle rings and 1½x2¼-in. inside angle rings about 8 ft. apart, the former serving especially to interrupt possible flow of water between the pipe and masonry. They are supported on steel trestle bents carried down to portions of the dam foundation built in advance of the rest of the substructures so as to receive them. At the upper end a concrete connection was designed between the pipes and the flume. On account of haste this was omitted and the junction was made with a wooden bulkhead which, although efficient, tends to diminish the discharge.

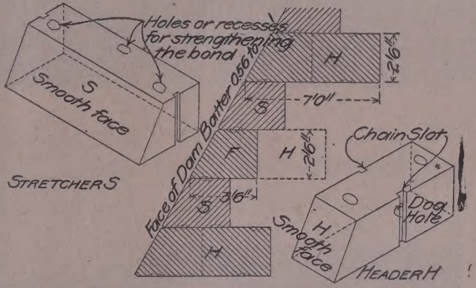
Ordinarily the low-water flow of the river does not more than one-quarter fill the pipes, but in one flood that has occurred since its installation they were scarcely adequate to carry all the water which rose to the top of the flume and overflowed slightly at the upper end of the pipes. The pipes are inclined about 1:10, and at the lower end were not running much more than half full when the upper end was submerged. Flanges are provided at the lower ends of the pipes to receive dished steel heads that will be bolted to them after the masonry in the dam has been carried up to enclose them. The pipes will be built solidly into the dam masonry and then filled with concrete. An allowance of $30,000 was made in the contract for the construction of the diversion works, which have so far proved efficient, the only leakage noticed in the flume or dams being a little at the head of the pipes.

The original design provided for the construction of the permanent dam with trestle scaffolds on the upstream and downstream sides to provide for material delivery tracks and derricks at El. 270. It also contemplated the use of steel derrick towers permanently built into the masonry and carried up to El. 285 as the dam progressed, above which height the masonry was to be completed by means of derricks and towers located on the falsework beyond the faces of the dam. None of this plant has yet been installed and the work is now being prosecuted chiefly with cableway service.

Vigorous work was commenced by the contractor on June 26, immediately after the award of the contract. One of the first operations was to build a standard-gauge spur track about 1½ miles long from the dam site to connect with the Harlem R. R. tracks at Katonah for the supply of materials. This track has a maximum grade of 2.75 per cent., and a maximum curvature of 12 deg. It required heavy cutting which was included in the items of the contract. The cuts and fills were about balanced, the former being as deep as 40 ft. There were also several trestles and all highway crossings were made above grade. The track terminates on the west side of the river at El. 310, near the end of the dam, and connects with sidings to the different shops, quarries and storage yards.

Simultaneously with the construction of the spur track, buildings were erected for the office, bakery, dining-room, dormitory and the different shops, and excavation was commenced for the concrete foundations of the compressor plant. The diversion dams and flume were built and excavations for the foundations of the main dam were commenced with a series of benches transverse to the axis of the dam and about 100 ft. apart extending across the valley and up both sides so as to cover the entire area of the structure.

The soil was excavated with pick and shovel and was removed at first in wheelbarrows, later in carts, then in bottom dump wagons, and finally with wooden skips and steel buckets. The skips and buckets were at first handled by two guyed derricks located in the old river bed. These had 70-ft. booms and reached far enough to dump the buckets beyond the limits of the slope.



Arrangement and Details of Concrete Blocks.

On Aug. 8, a 700-ft. Lidgerwood cableway was installed transverse to the axis of the dam near the middle point. It hoisted the buckets and skips and then dumped them at a point about 400 ft. beyond the axis of the dam where the material was convenient to be loaded and returned later to the dam for use as back fill. The dumping was at first accomplished by hand, requiring four minutes for each round trip of the 1½-yd. skip. Afterwards an automatic dumping device was installed which reduced the time required to three minutes. Another parallel cableway of 800-ft. span was installed on Aug. 20. Both of these cableways have since been taken down and moved transversely two or three times and now occupy the temporary position indicated on the general plan.

The work on the installation of the longitudinal Lidgerwood cableways three, four and five was commenced Aug. 7, 1905; Jan. 25 and Feb. 26, 1906, respectively. These cableways each have spans of about 1,300 ft., with a capacity of 10 tons. Their towers are all seated on the same sets of tracks perpendicular to the axis of the dam and thus enable them to move back and forth over the masonry commanding the whole area of the dam. The head towers are about 90 ft., and the tail towers 60 ft. in height, and the cables have a deflection of about 70 ft., bringing their lowest point at El. 365 or about 25 ft. above the crest of the dam, thus affording clearance for the finished work. Two of these cableways had previously been installed on the Wachusett dam, where they gave satisfaction and are considered by the contractors to be very efficient for this class of work. It is likely, however, that they will be supplemented by the system of derricks and surface tracks on trestle work provided for in the contract designs. Soon after the installation of the traveling cableways was commenced, the work was stopped by the injunction already mentioned, and after it was resumed the spoil was handled by the cableways and derricks.

The rock is overlaid with earth varying from 0 to 30 ft. in depth and averaging about 18 ft. in the bottom of the valley. The general character is gravel and clay, full of boulders, all of it being apparently a glacial drift which shows frequent well-defined markings on the surface of the rock. Some of the earth is so hard as to require blasting. In such cases holes are made with air drills, sprung with dynamite, and fired with black powder.

The rock is very irregular, with the strata mostly lying edgewise. Good, sound rock frequently alternates with soft rock, and when the latter is in thin seams and inclined away from the dam it may be allowed to remain. Otherwise it is excavated until the soft material disappears and the seams are thoroughly clean. This requires an average excavation of about 10 ft., sometimes extending to a maximum of 28 ft. Blasting is done with 60 per cent. dynamite, sometimes mixed with black powder, all charges being exploded by connections made with the electric lighting mains installed by the contractor.

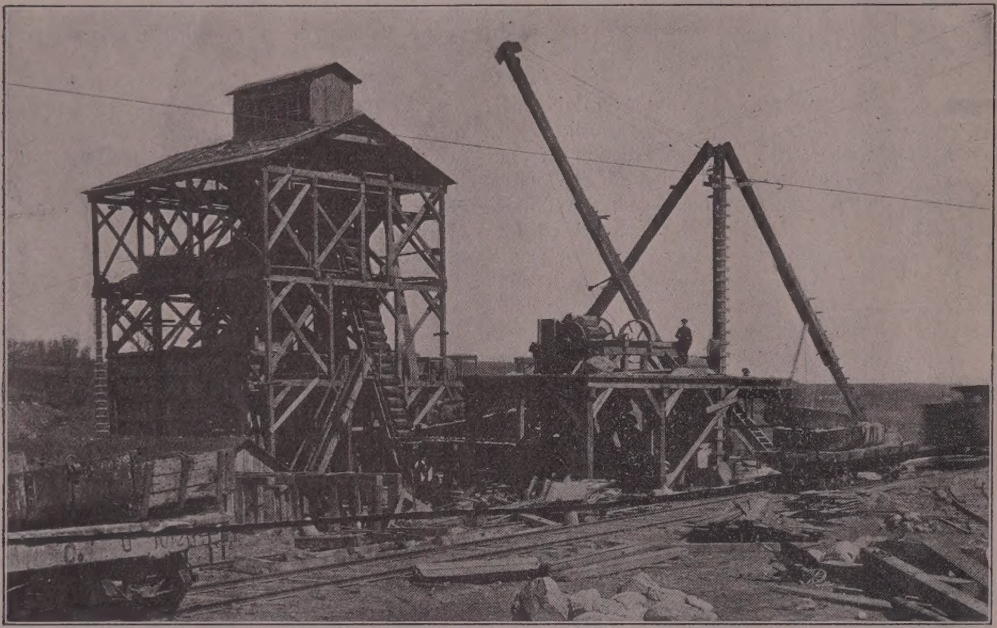
The 65,000 yd. of earth excavation is practically completed and the rock is excavated to sound strata over more than one-half of the foundation area. Its surface is left exposed except when the slope is such that it is necessary to step it off for the footings. Great care is taken to clean it thoroughly and to fill all open seams with grout or concrete. So far very few springs have been encountered and no great difficulty has been experienced with water.

The contractor's plant is principally located on the south side of the valley where the track from Katonah approaches the end of the dam. The power plant, air compressors, repair shops, concrete plant and block casting yard and storage, together with a quarry, are all within a few hundred feet of the head towers of the main cableways. The quarry is at El. 300 and has at present a vertical face about 40 ft. high and about 300 ft. long, which is being operated by three derricks and eight drilling machines. After the surface stone is removed, the strata are sound and suitable for use in the dam, the smaller pieces being used for concrete, and the larger ones being reserved for cyclopean stone. The concrete stone is delivered by 2½-yd. wooden skips on a surface track to the derrick at the crusher plant which dumps it on an elevated hopper whence it is chuted to the charging platform of a No. 9 McCully crusher, made by the Power & Mining Machinery Co., Cudahy, Wis. It has a capacity of 230 to 300 tons per hour, receives stone up to 22 in. square and delivers the crushed material to a steel bucket elevator made by the same company, which raises it to a cylindrical screen.

The material passing through the screen goes to the storage bins and that rejected by it goes to a No. 5 Gates and a No. 5 Austin crusher. After passing through them, it is elevated to a double concentric cylindrical screen with 2¾-in. and ⅜-in. meshes made by the Power & Mining

Machinery Co. The stone rejected by the ⅜-in. mesh goes to the storage bin and the material which passes this mesh is delivered to the sand bin, where it is supplemented by bank sand.

Advantage is taken of the slope of the hillside to reduce the height to which the stone is hoisted, and the loading platforms and crusher floors occupy successive levels terraced up from the surface of the ground and supported on braced trestle bents. The elevators, screens and storage bins are installed in a 50x30-ft. wooden tower about 80 ft. high, which also contains the concrete mixers. There are two stone bins and two sand bins, the former having a total capacity of about 225 cu. yd., and the latter a capacity of about 120 cu. yd. They are sufficiently below the screens to be filled by gravity and have hopper bottoms closed by steel gates operated by hand levers from the charging platform. A 20-in. horizontal conveyor belt furnished by the Boston Belting Co., is installed under each stone bin and receives stone through a chute delivering from the gate in the bottom of the bin.



Concrete Tower.

The stone is conveyed to a conical steel charging hopper with the upper end at the floor level. The gate in the bottom of the hopper being closed it is filled with stone up to a level determined by measuring with a gauge or template fitted to rest across the top of the hopper and project a certain distance below the upper edge. After the required amount of stone is received, sand is measured in a separate receptacle and then added to the stone in the hopper.

Cement in bags is stored in the building about 100 ft. away, which has a capacity of 5,000 bbl., and is delivered to the mixing floor over an elevated railroad and is emptied by hand into the mixing hopper. The mixing hoppers discharge directly into the 5-ft. cubical mixers, which receive measured quantities of water from a tank on the mixer floor. Concrete is discharged from the mixer into 2-yd. buckets, manufactured by The Cyclopean Co., Brooklyn, N. Y., which are pushed on narrow-gauge flatcars to the line under the longitudinal cableway and thence transported to the required positions on the dam.

The elevators, screens, conveyor and concrete mixers are all operated by clutches so that any one can be thrown in or out without interfering with the driving shafts, which run continually and are belted to a main shaft about 60 ft. long brought in a covered gallery from the engine house where there is installed an 18x22-in. engine built by the Chandler & Taylor Co., Indianapolis, which runs at 110 r.p.m. and is operated by air at 110 lb. pressure passed through a Foster superheater. With this plant it is expected that 1,000 cu. yd. of concrete can be mixed daily, thus affording abundant provision for all which can be laid in the dam.

Both sides of the dam are faced with cast blocks of concrete laid with 30-in. courses composed wholly of stretchers or with headers and fillers. The stretchers are 8 ft. long and about 3½ ft. wide at the bottom, the headers are 30 in. long parallel with the face of the dam and about 7 ft. wide perpendicular to it. The above dimensions are for blocks at El. 230, and vary in other parts of the work.

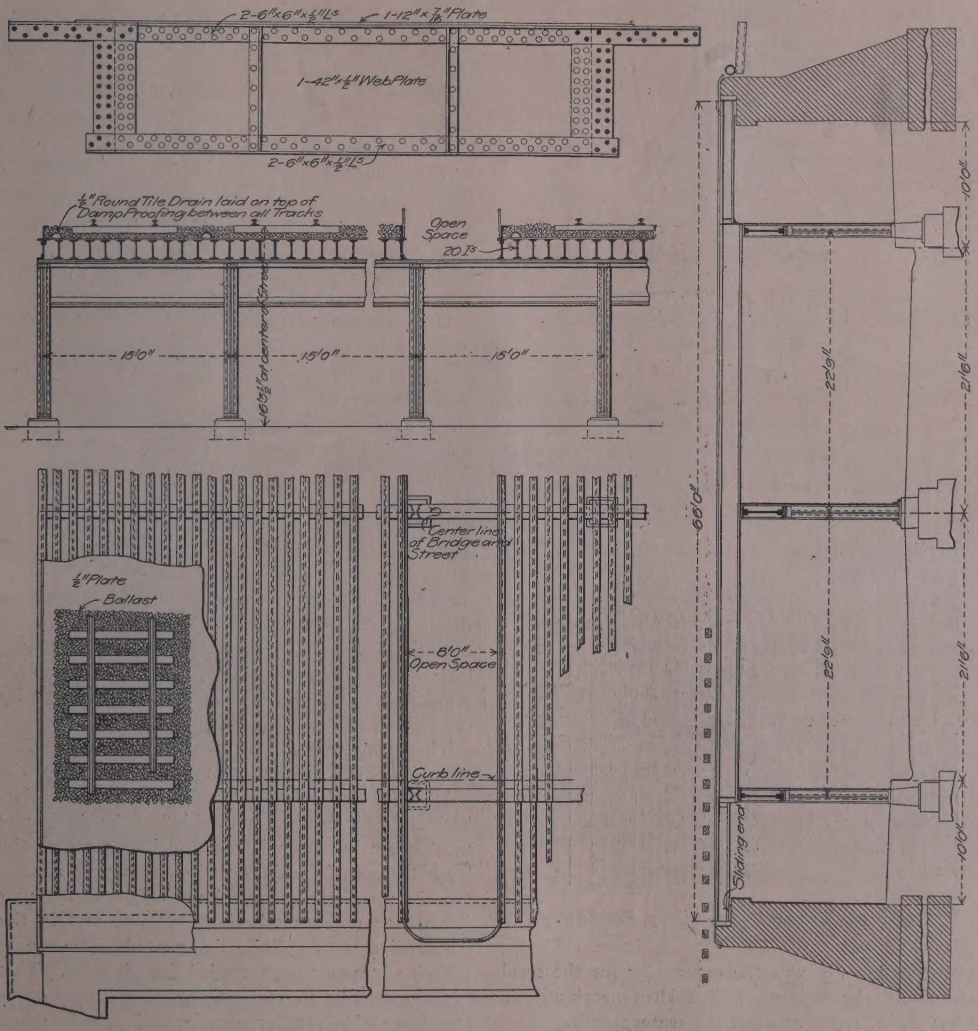
Their arrangement in the dam is such that the blocks are successively header, stretcher, filler, stretcher, header and so on, in any vertical cross section. The corners on the faces of the blocks are rounded ¾ in. and all joints are made ½ in. thick with the mortar raked out ¾ in. from the face of the stone. Shallow 6-in. holes are left in the upper surfaces of the stone to increase the bond, and vertical grooves about 2 in. deep and 4 in. wide are made across the end faces of all stones to give clearance for the hoisting chains. In these grooves small holes are cored to receive the hooks or dogs, so that no drilling or cutting is necessary to provide for handling them.

The maximum weight of the blocks is about 6 tons, and it is required that they should be at least three months old before being laid in the dam. Provision has therefore been made for casting these stones adjacent to the concrete plant, where a yard about 400 ft. long and from 60 to 160 ft. in width has been leveled at El. 286. Buckets of concrete are delivered from the mixing plant to the casting yard on a surface track which also carries two of the four trucks of a 12x20-ft. platform raised 6 ft. above the surface of the yard. The other trucks of this platform run on a parallel track 20 ft. from the first track. The bucket is hoisted by the derrick and dumped on the elevated platform, from which the concrete is shoveled into moulds arranged in four lines parallel with the track, two lines between the tracks and one line outside of each track. The longest lines have room for fifty moulds and men working on the platform can fill moulds on all four sides of it at once.

The moulds are made with one inclined and three vertical movable sides set up loosely on the bottom and held there by wedging and by gravity. The sides and bottoms are complete separate panels made of 2-in. planed longitudinal boards and transverse battens. Each long side piece has four vertical transverse pieces one at each end and two equidistant intermediate ones. The long sides project beyond the short sides, against the carefully squared end of which they abut and are held by ⅝-in. horizontal rods at the top and bottom. The intermediate batten pieces are secured by single tie rods at the top, above the upper edge of the mould, and by pairs of wedges at the bottom, which engage plates fastened to projections of the floor of the mould. These are adjusted so as to partly hold the mould in position and resist the pressure from the wet concrete. The exposed faces of the blocks are cast against steel plates which secure a very smooth and excellent finish of the 2⅓:4⅔ concrete, which is mixed wet with Giant cement and is very carefully spaded back as the mould is filled so as to prevent any stones from appearing on the surface of the block.

Excavation for Foundations of Main Dam.

The largest mould has a capacity of 57 cu. ft. and as many as 65 moulds have been filled in one day by a force of six men on the traveling platform, three in the moulds and two on the cars. After having set 30 hours the sides of the mould are stripped from the blocks and after five days the concrete is hard enough so that they can be picked up and removed from the mould bottoms, but it is not then safe to turn them, although it is sometimes done by carefully elevating a plank which has been previously placed under them for this purpose. When ten days old they can be safely turned over and then handled by the derricks and piled in tiers two or three courses high for storage until ready for use in the dam. The concrete yard is served by two stiff-leg derricks and three guyed derricks with booms 55 and 65 ft. long. These interlock so as to command the whole area; but it is intended to prolong the booms 10 ft. so as to give a better service.



Part Plan and Section, Elevation and Girder for Superstructure.

The power house is located about 1,500 ft. from the concrete plant, and in it are installed three Rand compressors, one of them of 120 h.-p., and two of them of 500 h.-p., each with intercoolers. There is an Ames engine operating a Westinghouse dynamo for the contractor's electric light plant and there are two large Deane pumps which supply river water to a 15,000-gal. circular wooden tank at El. 380, which provides water for the contractor's purposes, and for the domestic use at the camp. The engines are operated by steam from three 365-h.-p. Aultman & Taylor boilers. Between the power plant and the concrete plant there is located a smith shop where three fires and a steam hammer are operated by compressed air, and a machine shop with lathes, planes, drills and bolt cutters and other tools operated by an Erie City Iron Works engine driven by compressed air and served by a differential trolley hoist traveling from end to end. Adjacent to it there is a carpenter shop with belt-driven saws and planes where the moulds for the concrete blocks are made and other woodwork is done. Besides the plant above enumerated there have already been installed one stiff-leg derrick and two guyed derricks on the dam, three derricks in the quarry and one at the north end of the dam to erect the tail tower of the third cableway. Five other stiff-leg derricks have also been assembled at the south end of the dam in readiness to be transported bodily by the cableway and placed on the line of the dam as required for handling the concrete there. Nearly all of these derricks have booms from 50 to 60 ft. in length with a capacity of 10 tons. All of them are fitted with swinging gear and are operated by Lidgerwood and American Hoist & Derrick Co.'s hoisting engines. About twenty Rand drilling machines are used in the dam foundations and in the quarry and additional drills and derricks are being installed in a second quarry which the contractor has recently opened at the north end of the dam. Cyclopean concrete masonry is now being laid in the foundations of the dam and it is proposed to prosecute the work with great vigor. The contractor's present force amounts to over 400 men, and will be increased as the work progresses.

Mr. Walter H. Sears is the chief engineer, and Prof. William H. Burr is the expert engineer for the Croton Aqueduct Commissioners. Mr. G. G. Honness is the acting division engineer, and Mr. Daniel Ulrich, Mr. C. M. Clark and Mr. C. S. Haynes are assistant engineers. Plans and specifications for the dam were prepared under the supervision of Mr. J. Waldo Smith, then chief engineer, and Mr. A. D. Flinn, general inspector for the Commission. The work is being executed under the direction of Mr. James Winston, of the contracting firm, and Mr. M. J. Look, engineer and superintendent.

A Thirty-three Track Bridge at Chicago.

A large number of Erie main line, yard and local tracks substantially parallel to each other and as close together as possible are concentrated at 51st St., Chicago, and cross it nearly at right angles with a vertical clearance of about 16 ft. above the surface of the street. The tracks are carried on fills on both sides of the street, which is 43 ft. wide between curbs, but over it they are carried on a deck bridge which consists of a platform 67 ft. wide and 433 ft. long parallel with the axis of the street. The platform has three lines of longitudinal plate girders parallel with the axis of the street, which are supported on one row of columns in the center of the streets and on one row at each curb.

The girders carry across their top flanges 20-in., 80-lb. I-beams 15 in. apart on centers, and about 46½ ft. long. Both ends of these beams are extended by 12-in. I-beams supported at the outer ends on a retaining wall at each side of the street. The top flanges of the beams are covered with a continuous horizontal plate ½ in. thick, countersunk-riveted to them. The outer edges of the bridge, transverse to the axis of the bridge, are provided with a fascia girder 30 in. deep which confines 10 in. of sand ballast spread over the surface of the platform. In this ballast the ties are bedded so that the tracks can be arranged in any position desired. As the street underneath the tracks is enclosed by solid walls on both sides and by the solid floor overhead it presents a tunnel-like appearance and is very dark. Some light, however, is admitted through four wells 8 ft. wide which extend across the full width of the bridge and are enclosed by fascia girders and gas pipe hand rails similar to those on the outer sides of the platform.

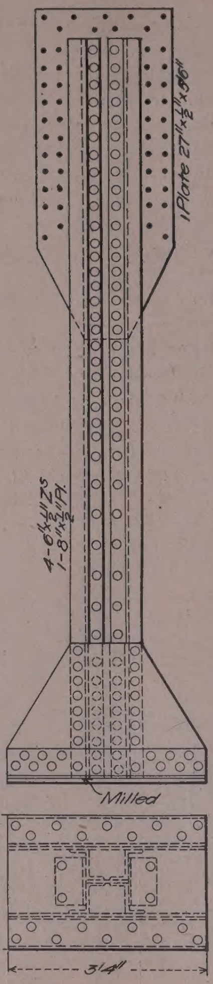
The longitudinal girders have 42-in. web plates ½ in. thick and are made in sections 14 ft. long, with the ends of the webs field-riveted with double-cover splice-plates to projections of the column webs, thus making very stiff connections between girders and columns. The bottom flange angles are cut to clear the columns and the top flange angles are made to splice across the column tops, being field-riveted to the column webs and having their ends alternately projecting beyond the column centers on opposite sides of the girders. Both top and bottom flanges are made of pairs of 6x6x½-in. angles and the top flange only is reinforced by a full-length 12x7/16-in. cover plate.

The twenty-eight center columns are about 13 ft. high over all, and have an H-shaped cross-section, made of four 6x½-in. Z-bars and one 8x½-in. web plate, the latter being made in two sections so that the upper one can be extended beyond the sides of the columns to receive the connections to the longitudinal girders. Their bases are extended to a width of 40 in. and are stiffened by ½-in. gusset plates riveted to both flanges of the columns. They are seated directly on the masonry pedestals of separate piers rising just above the surface of the street. The side columns are similar to the center columns except that their bases are not extended and the feet of the columns are seated directly on cast-steel pedestals about 2½ ft. high, with slightly enlarged bases set on planed ¾-in. steel plates on the pier pedestals, which do not rise above the bottoms of the gutters. Each pedestal is secured to the masonry by four 1½-in. anchor bolts 18 in. long, which pass through the base plate only, and by one 1½-in. anchor bolt about 6 ft. long, which passes through both base and cap plates of the pedestal and engages the upper ends of a pair of vertical angles riveted to the webs of the Z-bars in the foot of the column.

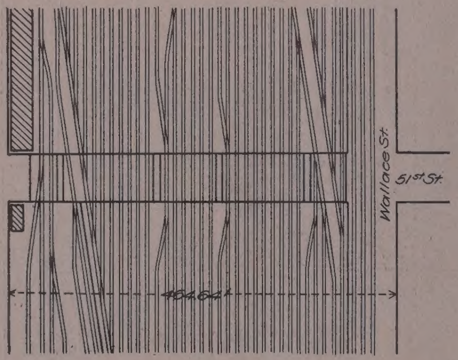
The transverse I-beams are connected to the longitudinal girders by two field rivets through the adjacent flanges at each intersection. Generally they were shipped in groups of three, shop-riveted to the floor plates 44½ in. wide and 46 ft. 10½ in. long. The rivets are pitched 12 in. apart in each flange, staggered, and are countersunk in the ½-in. deck plate. The transverse edges of the plates are butt-jointed with ½-in. clearance at the center line of every third beam, where one row of holes was left open for field rivets. Pairs of vertical web-connection angles are riveted to the ends of the I-beams, and their outstanding flanges are connected by single horizontal 6x4-in. angles 3 ft. 2¾ in. long, which are shop-riveted to them. These angles serve as shelf supports for the 12-in. I-beams 9 ft. 8¾ in. long, which carry the deck plates across the sidewalk. These I-beams have web-connection angles filed-riveted to those on the 20-in. I-beams, and were shop-riveted to the deck plates in groups of three like the former. The deck plates project 6 in. beyond the ends of the beams to form sliding aprons resting on the tops of the back walls of the abutments. The lower flanges have shoe plates countersunk-riveted to them, which rest on the abutment walls and are beveled to correspond with the inclination given to the beams to provide for drainage. The total steel weight of the bridge is 991,801 lb.

Great pains were taken to provide a thorough waterproofing for this bridge so as to prevent any danger of leakage or dripping upon the street below. The upper surface of the floor and the inner sides of the fascia girders were thoroughly cleaned with a torch just before the application of the waterproofing. Then hot Hydrex compound was spread over it with a mop covering about one square yard with each application. The Hydrex felt, in rolls 36 in. wide, was applied to the mopped surface in courses laid transverse to the axis of the bridge, reaching continuously across the full width of the floor and extending up vertically 4 in. on the webs of the fascia girders. At the end of the bridge the felt was applied in four-ply layers. Successive applications were made with the edge of the felt moved back 18 in. so as to give an overlap of 2 in., thus presenting a sort of channeled surface and maintaining everywhere a thickness of four ply, each ply lapping those below it 18 in. Each ply was laid in the hot compound thoroughly mopped over the preceding layer and was well rolled while hot. The longitudinal joints made by the ends of the successive rolls of felt were lapped 12 in.. The sides of the fascia girder were counterflashed with two ply of felt laid in hot compound and extending from a point above the first flashing to a distance of 6 in. beyond the fascia girder on the floor of the bridge. Special care was taken to cement the flashing thoroughly and after it was completed the surface of all the flashing and floor was thoroughly covered with hot compound and protected by old bricks laid side by side. The operations of this process were rigidly specified and very carefully carried out, the result being that the work is considered thoroughly waterproofed and satisfactory by the contractors and engineers.

The design and erection of the bridge were under the direction of the Engineering Department of the Erie Railroad, Mr. F. L. Stuart, chief engineer and Mr. Mason R. Strong, engineer of bridges and buildings. The McClintic-Marshall Construction Co. was the contractor for the steel work and the Hydrex Felt & Engineering Co., New York, superintended the waterproofing.



Column Supporting Transverse Girder.



Plan of Tracks Crossing Bridge.

Precise Leveling between Grafton and Chicago, Ill., done in connection with the investigations of a 14-ft. waterway between Chicago and St. Louis, covered a length of 334.52 miles. The probable error of the whole line is 13.55 mm. Great care was taken to equalize foresights and backsights and in keeping the bubble centered while reading the rod. An original and a check reading were always taken on the back rod, one immediately before and one immediately after the reading on the fore rod, and their mean was used in the final reduction. A large umbrella was used to protect the instrument from the sun, and another, held by a steel rod stuck into the ground, kept off the wind. Strong steel pins made by local blacksmiths, were used for rod supports; the socket at the top of each pin was formed by a die punch which was carried by the party.

The Present Status of the Steam Turbine.

Among the papers read at the recent meeting of the National Electric Light Association, was a very interesting report by Messrs. W. C. L. Eglin, I. E. Moultrop, J. D. Andrew, W. E. Moore and A. C. Dunham, giving the results of their investigations during the past year into the development of steam turbines and turbine maintenance. The turbine situation has very materially changed since their first report, reviewed in this journal on June 24, 1905. To-day the steam turbine is recognized as a standard piece of apparatus, and turbines of some type are being installed in nearly all of the newer power-houses. During the discussion at the meetings of the committee it was decided that it was unnecessary to continue any further tests on economy, as there were now so many turbines installed in regular operation giving satisfactory results.

Curtis Turbine.—During a visit to the Lynn works of the General Electric Co., it was found that the most important feature is the large increase in the number of the smaller sizes of turbines now being built, sizes from 25 to 300-kw. of the horizontal Curtis type. A number of these turbines were being controlled by a mechanical valve mechanism of a new type, being developed specially for this class of turbine. There was a very noticeable increase in the number of turbines being manufactured in sizes up to 1,500-kw., as well as the smaller types.

During the inspection of the Schenectady works of the same company a number of improvements in the mechanical construction were noted. The larger wheels in some cases are being made from steel plates or boiler plates, two plates being bolted to a spider, the spider being placed between the plates and the buckets riveted at the outer edge with the flange of the bucket sections on the inside of the wheel; the two sets of buckets are so arranged that they have a smooth external surface, reducing the friction of the wheel.

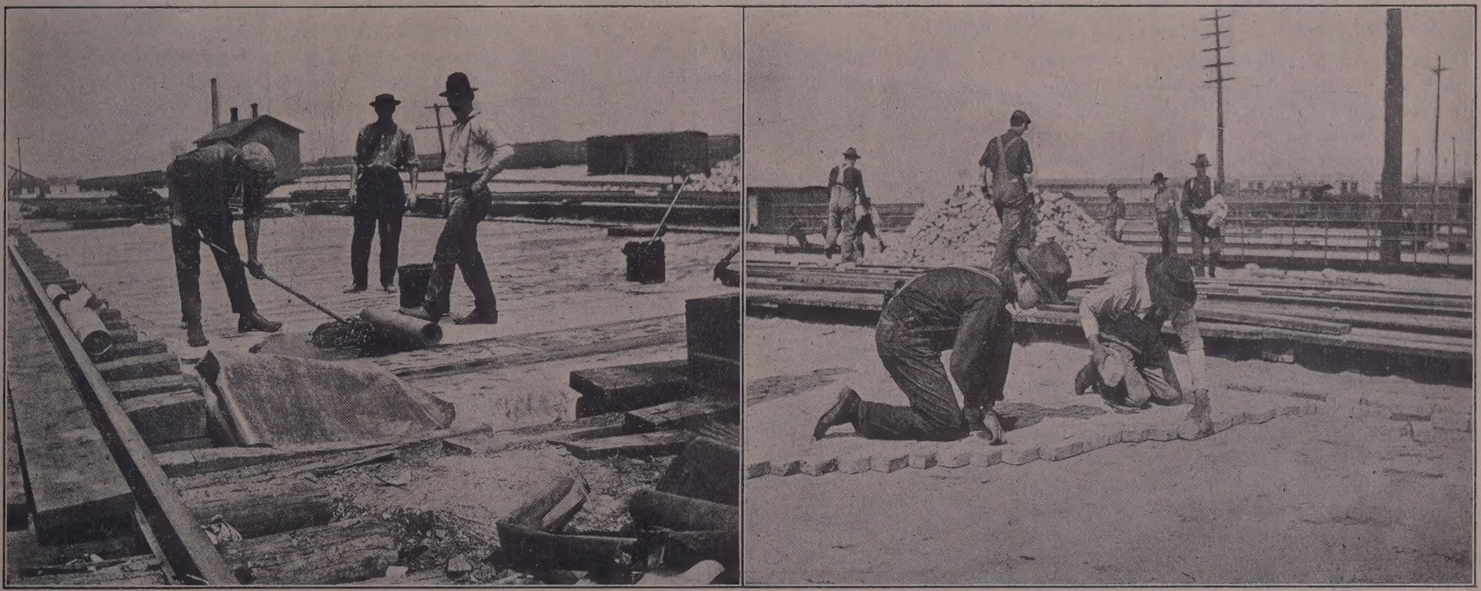
The committee discussed with the engineers of the General Electric Co., both at Lynn and Schenectady, the various features of the Curtis turbine, and particularly such parts as had required special attention during the past year in regular operation.

There are now being manufactured three distinct forms of mechanical valve gear. First, the valve gear designed by Mr. Richard H. Rice has had some improvements added. The hydraulic mechanism has been introduced into some of the largest sizes of turbines with satisfactory results. On the smaller-sized machines a single cylinder is used to operate all of the valves, and in the larger sizes two cylinders are used. The single cylinder is now recommended for all sizes. This cylinder will be so proportioned that it may operate from the regular gravity oil supply when specified.

The changes in the mechanical type of valve gear on vertical turbines made at Lynn have been in the interests of simplification, elimination of noise from the gear drive, and improvement of appearance; and with these three major changes are incorporated such changes of minor details as experience has dictated. The gear still consists of a number of units, each operating a valve in such manner that, except momentarily, it is always wide open or quite closed. Each unit consists of a pair of reciprocating pawls, one adapted to open the valve, the other to close it; a governor-controlled shield-plate, which determines by its angular position the engagement of one or the other pawl and consequently the opening or closing of the valve; and the valve itself with stem and cross-head. All the pairs of pawls are reciprocated in unison by a common moving support suitably driven from the turbine shaft. The reciprocating connecting-rods actuating the pawls in the later form are driven by worm gearing located near the middle of the shaft instead of near the top, thus rendering the driving parts simpler and less conspicuous. The pawls, instead of engaging a cam-plate, which in turn actuates the cross-head of the valve, engage this cross-head directly, thereby much reducing the number of parts and the linear motion required of the pawls.

The new mechanical gear used on smaller-sized turbines consists of a system of units, each unit having a valve with cross-head and block, and an actuating dog capable of opening or closing the valve through engaging the block, and driven at reduced speed from the turbine shaft. Each valve has but two positions of rest—wide open and entirely closed. The system of operation is in this respect that at present used on the larger Lynn machines.

The dog itself consists of a small eccentric strap with projecting arm about 6 in. long, provided with two hooks, one at its outer extremity, adapted to pull the cross-head block toward the eccentric shaft and open the valve, and the other located half-way between the one first named and the shaft, adapted when suitably engaged to push the cross-head block away from the shaft and close the valve.



Placing Waterproofing and Covering It with Brick on a Thirty-three Track Railroad Bridge.

The eccentric shaft runs counter-clockwise, and by it is imparted to the dog a motion circular at one end and at other points determined by a composition of this circular motion with the generally rectilinear movement of the engaged element. The block is provided with two shelves or landing-springs, and these determine the engagement of the opening or of the closing-hook. A displacement of the dog along the axis of the eccentric shaft will cause it to come in line with one or the other of these landing-springs. If it engages with the one nearer the valve, the hook at the outer extremity will engage when the dog is in its forward position. As the circularly driven end swings downward and backward this hook pulls the block back and the valve opens. When it reaches its rear dead point the opening-hook, still resting upon the valve-end landing-spring, acts as a fulcrum and the upward movement of the eccentric causes the closing-hook, pivoting about this valve-end landing-spring, to rise so that it misses its connection with the block and does not close the valve. Conversely, if through axial motion the other way the dog lands upon the shaft-end landing-spring at the end of the outward movement of the eccentric, the upward and forward movement of the closing-hook will close the valve, and the dog, pivoting about this shaft-end landing-spring, will miss connection with the opening end of the block and will therefore leave the valve closed. It will thus be seen that it is merely necessary for the governor to move the dog along the direction of the eccentric shaft axis in order to cause it to open or close the valve. Friction load on the governor is almost completely eliminated by the fact that the parts which have to be moved endwise by the governor are revolving in their bearings. A straw taken from a broom will suffice to move the 100-kw. valve gear back and forth.

Some further details arising directly from the design are as follows: The full width of the engaging knife edges is always employed; the only impact is upon landing-springs of the simplest form and adapted to receive it; within limits set by mechanical clearance it is impossible for the valve to move forward or backward under influence of steam more rapidly than the gear drives it; and the parts employed are very few, simple and substantial.

In case this gear is used in a horizontal position, gravity pulls the dog toward the blocks and in addition the friction of the rotating eccentric aids this action. In case the gear were to be used in a vertical position a slight endwise clamping of the dogs, accentuating the tendency of the shaft to carry them around in the proper direction, is sufficient to render the action certain without the intervention of gravity. The gear has thus far been actually used in a horizontal position only.

There have been some minor changes in the buckets. The principal change in this direction is the increase in speed over the former speeds of the buckets; 325 to 350 ft. per second is being increased in some cases to between 450 and 460 ft. per second.

A lengthy discussion was held on the relative advantages of oil and water for step-bearings. It is the consensus of opinion that water is most desirable, although special care should be taken that the water is clean and free from grit of any kind. Oil will give better all-round results, and in future designs the step-bearing will be outside the casing for oil-bearings. The step-bearing as so placed with the packing above it is accessible without opening the base, and with this arrangement a single oil pump will take care of the step-bearing, upper bearing and hydraulic valve mechanism. When water is used for the step-bearing a wood-lined sleeve is recommended for the bearings, but when oil is used a babbitt-lined sleeve is recommended.

At the committee's previous meeting with the engineers of this company the clearance between the buckets was discussed at some length, and the opinion was then expressed that the clearance of practical limits had no effect on the efficiency. It has been demonstrated that this clearance can be increased with advantage, and the committee requested the company to consider increasing the clearance on all sizes, and a list of revised clearances is appended.

Clearances of Curtis Turbines.

Turbine.	1st stage.	2d stage.	3d stage.	4th or 5th stage.
500-kw., 1905	0.6 in.	0.6 in.	0.6 in.	0.6 in.
500-kw., 1906	0.10	0.10	0.10	0.15
5000-kw., 1905	0.10	0.10	0.10	0.20
8000-kw., 1906	0.20	0.20	0.20	0.28

Note—The clearances of sizes of turbines between 500-kw. and 8000-kw. will vary between the limits shown.

The committee also discussed the question of testing turbines, condensing and non-condensing. This does not appear to be practicable at the present time in the works of the manufacturers, so the committee recommends to all purchasers that before turbines are put into regular service they be tested both condensing and non-condensing, not for the purpose of determining the steam economy, but only to test the mechanical parts.

The steam packing of the middle bearing has not proved entirely satisfactory and the design of this has been changed.

The emergency stop now used consists of a ring which is slightly unbalanced and normally held in concentric position by a spiral spring. When the speed increases beyond the predetermined limit, the unbalancing overcomes the spring, and the ring flies into an eccentric position where it delivers a blow to a lever which trips the automatic stop valve. This device is very simple and positive.

The committee were unable to suggest any changes in the casing which would improve its tightness without interfering with other functions, particularly the inability to remove sections for inspection. The prevailing opinion was that the best remedy was to examine the casing carefully after the turbines were set up and test for tightness by means of vacuum, marking all leaks, using a filler of paint or wax applied hot and when the casing is still under a vacuum.

The changes in the balance after the turbines were in operation have been shown to exist in a great many turbines. This seems to be common to all types of turbines. Apparently this is in almost all cases attributed to the generator, the insulation between the conductors being primarily responsible.

The total number of turbines of the Curtis type manufactured by the General Electric Co. shipped or on order is 592 units, an aggregate of 580,325 kw. Of these, 385 units are of 500 kw. or larger.

Westinghouse-Parsons Turbine.—The Westinghouse Machine Co. now has in operation 144 units, or a capacity of 122,270 kw. It has shipped or on order 130 units, equivalent in capacity to 200,250 kw., making a total number of 274 units, an equivalent capacity of 322,520 kw.

The changes in the design since the last report of the committee consist particularly in the type of lacing used in the blading. The lacing now in use in cross-section is similar to the "apostrophe" and the thin edge is bent over between each blade insuring uniform spacing and a tighter joint than was possible with the flat lacing twisted. This makes a more rigid construction and is easier applied. The lacing is not continuous, but cut in sections so as to allow the lace freedom to expand without interfering with the spacing between the blades. The extra lacing which was introduced at the joints has been abandoned. It is claimed that where the blades touch the casing of the turbines the cast-iron casing had been cut and the blading had not been destroyed.

The double-flow turbines that were experimented with during the committee's previous visit have been very materially changed in both design and construction. The first stage consists of an impulse wheel with two sets of buckets, steam being admitted through three nozzles, two arranged at the top and one at the bottom of the casing. The steam after leaving the impulse wheel passes on to a series of Parsons blading. After passing through a second stage, assuming that the impulse wheel is the first stage, the steam is divided, continuing in the same direction through the blading, the balance being carried through openings in the cylinder to which the blades are attached to the opposite end of another set of Parsons blading and in this way balancing the thrust.

The committee saw one of these machines in regular operation in the works of the Westinghouse Electric & Manufacturing Co., apparently giving satisfactory results. The advantages claimed for this machine are that it obviates the necessity of the use of large balancing pistons and it materially shortens the length and reduces the diameter, making the machine more compact; for these reasons the design particularly lends itself to the larger sizes. Sufficient information has not been obtained to know whether the economy will be as good or better as compared to the standard Westinghouse-Parsons type. Efforts are being made to push forward the completion of the experimental machine so as to obtain necessary data on all of the details. It is not expected, however, that this machine will supersede the machines that are now being manufactured, but in all probability it will be more suitable for certain sizes.

Allis-Chalmers Turbine.—The committee states that the principal difference between this type of turbine, illustrated in this journal on Dec. 16, 1905, and the Parsons turbine is in the mechanical construction, balancing pistons, blading, the governing device, and some other details. The workmanship of all of the parts of this machine is excellent, and the uniformity of spacing between the blades, the height of each blade and the gauging are most accurately maintained. The casing has been designed with great care to maintain the spacing, and to allow for proportionate expansion due to various changes in temperature to which it may be subjected.

On account of the high speeds of steam turbines and their generators, persons not accustomed to such speeds naturally feel some anxiety as to their perfect safety. This feeling has not been diminished by accidents that have occurred, and, for the purpose of reassuring purchasers, the Allis-Chalmers Co. has adopted the policy of testing every turbine and generator in its works to a speed 20 per cent. in excess of the rated speed, thus subjecting the material to stresses 44 per cent. above the normal. This overspeed test taxes the machine as it can not be taxed in practice, as even should the main governor fail to work, the safety governor will stop the turbine long before it reaches such a speed.

A 5,000-kw. turbine has been examined by the committee which was installed in the Williamsburg station of the Brooklyn Rapid Transit Co. This machine was started March 27 and has been running practically constantly ever since, carrying from full load to 50 per cent. overload. The machine runs very smoothly and is apparently giving satisfactory results. There was an accident to the first rows of blades at the high-pressure end due to a foreign substance getting into the machine. The cause of this was due to the carelessness of some person leaving in the casing a knife when the machine was being erected. This was discovered on April 25 after the machine had been in operation practically one month.

Shortly after starting up on the morning of April 25, a peculiar noise was heard in the turbine cylinder and the turbine was shut down and opened up. It was found that a piece of steel had become lodged between the spindle and the shroud of the first row of stationary blades and, acting like a lathe tool, had cut into the body of the drum for a width of about three-eighths of an inch and for a depth of nearly three-sixteenths of an inch, this cut being alongside of and opening into the groove which holds the first row of spindle blades as shown on the attached sketch. This had loosened a calking strip which held the ring of blades in place. For a distance of five or six inches this strip had come partly out of its groove, thereby loosening the ring of blades. This latter, under the influence of centrifugal force, had bent outward so that the channel-shaped shroud ring had rubbed hard into the bore of the cylinder. This rubbing had been so severe that the flanges of the shroud ring had worn almost down to the heads of the riveting which holds the shroud ring to the blades. The most important point is, not a single blade had come out or even become loosened or injured in any way.

The remedy consisted of removing one ring of blades, closing the cylinder and putting the turbine back into service; and at a convenient time a new set of blades will be installed. An investigation as to the cause of this mishap showed that the piece of steel which had cut the groove in the shaft was apparently one of the leaves of a pocket-knife handle. A further search discovered the remainder of the metal parts of the knife, but the outer covering of the handle had disappeared. The large blade of the knife shows that it also had been rubbing hard.

This company has shipped or under construction 18 turbines of a total rating of 28,500 kw.

Mr. I. E. Moultrop contributes to the committee's report some notes that he made upon the turbine situation in England and on the Continent during a recent trip abroad. There can be no doubt as to the status of the turbine as a prime mover in the generation of electrical energy by use of steam, for all of the recently designed stations which were visited were equipped with turbines, and some of the older stations, built originally with engine-driven units, are being increased in capacity by the installation of turbine units. The only observed instance in which this is not true is that of the Metropolitan station in Paris where the station is being completed by the installation of one large engine-driven unit. This station was originally designed for, and about seven-eighths equipped with, engines, and doubtless the design of the station and the local conditions would, in this instance, make the installation of a turbine very inconvenient. It is rather interesting to note that in interviews with the leading engineers no question was ever raised as to the comparative merits of engines and turbines for electric light plants.

As an illustration of the standing of the turbine in England, it will be interesting to mention that the British Government decided the first part of this year that many of the naval vessels now under construction should be equipped with turbines in place of engines for propelling the boats.

The horizontal-shaft type of turbine is practically the only one used, and from the European engineer's viewpoint, it fills their requirements much better than a vertical-shaft machine could possibly do. It is quite common practice with them to mount the exciter for an alternating-current unit on an overhung extension of the generator shaft and this method of excitation seems to give very good results. It tends to simplify the station equipment, has the advantage of driving a very small generator with the same economy as that of a large unit, and without any of the losses from the conversion of energy such as would occur in a motor-driven exciter. So far as could be learned, no serious difficulty has been experienced from fluctuations in the excitation voltage by reason of speed variations of the turbine caused by sudden or wide changes of load on the main generator. Another advantage of the horizontal type was noticed in the municipal station as Essen where they furnish both high-tension alternating current for power and lighting and 600-volt direct-current for trolley cars. The peaks on these two systems do not overlap. A 5000-kw. turbine unit is installed with an extra long generator shaft carrying a 5000-kw. alternator, a 1500-kw. direct-current generator, and also the exciter for the alternator. This combined unit was only a few feet longer than it would have been had the direct-current generator been omitted, and the combination saved the installation of a 1500-kw. turbine to drive the direct-current machine, making the station simpler in its arangement and cheaper to build.

No difficulty with the lubrication of horizontal bearings was found anywhere. The usual practice is to supply these bearings with an abundance of oil under considerable pressure so that the shaft is partly floated, and in addition the bearings are usually water-jacketed.

The regulation of the turbine is almost invariably accomplished by means of a governor controlling one valve in the steam-supply pipe, the steam being either throttled or admitted in puffs. The majority of the manufacturers use the latter arrangement. None of the manufacturers is attempting to regulate by cutting in or out a series of nozzles and this portion of the turbine construction is therefore very simple and positive. Close regulation is very easily obtained and turbine-driven alternators of different sizes were seen working in parallel, also working in parallel with engine-driven units and apparently without setting up cross-currents sufficient to be at all troublesome.

Much attention is being paid at present to the matter of blading turbines. Nearly all of the manufacturers are using blades made of extruded or drawn metal and secured to the shaft of the rotor by calking strips, and there seems to be no difficulty in obtaining a secure fastening in this manner. The Parsons Co. and its licensees, both in England and on the Continent, are lacing the turbine blades near their outer ends with an oval lacing inserted in a manner similar to that adopted by the American Westinghouse people some time ago. This method of lacing seems to work satisfactorily so long as the blades do not rub, but apparently all of the manufacturers who are using this construction are having trouble with the stripping of blades whenever the rubbing becomes very excessive. It was noted that in all of the stations visited, where this type of blading was used, there has been experienced, at some time or other, more or less trouble from the stripping of blades. This is one of the points that is now receiving a good deal of attention by both turbine designers and turbine users.

In the Zoelly turbine, the blading is done quite differently; the blades are cut out of strips of flat sheet steel, which is first milled wedge-shaped so that when finished the tips of the blades are much thinner than their roots. The blades are then shaped, polished, inserted and riveted into a light steel disc. No shrouding or lacing is used to support the blades. As no large installations of Zoelly turbines were visited, it is impossible to say from observation whether or not they had much trouble from losing blades, but from the fact that this machine is quite short for its diameter, it would be natural to suppose that there would be less trouble from stripping blades than in machines of the Parsons type.

The Willans & Robinson Co., at Rugby, have brought out a new form of blading which is attracting much attention and is one that would seem to be less liable to blade troubles than the older form of Parsons blading. They are using the Fuelleger and Sankey patents and their blading is practically identical with that of the Allis-Chalmers Co. in this country. It may be interesting to note in this connection that this method is so well thought of that the Willans & Robinson Co. have just closed a contract with the Cunard Co. to furnish the blading for the two new 25-knot turbine boats that the company is now building.

There seems to have been very little progress made in the matter of steam consumption of turbines during the past year. The best record of economy appears to be that of the Brown-Boveri 5000-kw. machine installed in Frankfort a year or more ago. Apparently, the manufacturers have given more attention in the past year to the matters of standardization and of continuity of service than to economy requirements.

Improvement has been made in the design of turbine-driven alternators, chiefly in the matter of ventilation and eliminating noise. It now seems to be the general practice to enclose the alternator entirely and provide forced ventilation either by means of fans on the shaft at either end of the rotor which pull the air in from the ends, force it through the machine and discharge it through a short funnel at the top of the housing, or air is forced in by an external fan at the bottom of the housing and through the generator and then is allowed to escape through a short funnel at the top.

Direct-current turbine-driven generators are now being built as large as 2000-kw., which give very good results. The Brown-Boveri Co. succeeds in getting a good commutation in these machines, apparently, by using large, well-built commutators and setting one carbon brush in advance of the others on the brush holder to take what little sparking there may be at times. The Parsons Co. builds a grooved commutator and uses copper brushes. It also finds it desirable to set one brush a little in advance of the others on the same stub. Large direct-current generators of both makes were seen in operation and in all cases the commutation was very satisfactory, and, in spite of the high speed, the wear on both commutator and brushes seems to be remarkably small.

The British Westinghouse Co. has manufactured quite a number of turbines of the double-flow type, and installations of this type were seen at Brighton municipal station and the Neasden station and Lots Road station supplying current to the underground system of London. The chief advantage of this type is that the balancing pistons are dispensed with. Steam is brought to the longitudinal centre of the rotor and flows toward either end. It first passes through what is practically a Curtis single stage at either side of the steam inlet and then through the usual Parsons type of intermediate and low-pressure stages. The result is that the length of the rotor is materially lessened, and by making each end of the rotor do one-half the work, the steam pressure acting in opposite directions balances the rotor and thus eliminates end thrust. This type requires two separate connections to the condenser and seems to give little trouble provided the vacuum is maintained exactly the same at either end of the rotor. This construction of the rotor materially reduces the length of the machine and because it is so short there is less difficulty from unequal expansion in either the rotor or the casing than in the case of machines built on the single-flow principle.

Another new type of turbine was seen at the works of the Allgemeine Elektricitäts-Gesellschaft which gives promise of developing into a very satisfactory machine. It is a modified Curtis turbine with horizontal shaft and is somewhat different from the machines previously turned out by this company. A 3000-kw. machine was seen in the company's turbine works which had been running under test for a considerable period of time. The rotor is built up with two regular Curtis double stages followed by eight Curtis single stages. The blading is formed from drawn or extruded metal. The wheels of the rotor are each made up of two steel discs with a groove in the periphery to receive the blades and the whole structure is then riveted solidly together. Special care is taken in building up the rotor to have it in good running balance, and before the rotor is assembled in the machine it is tested out in a balancing machine at the speed under which it is normally to operate. The peripheral speed of this machine is somewhat higher than in any of the other existing types of turbines and, to insure that it is not exceeding safe limits, the rotor is tested under a speed much higher than normal running speed before being assembled in the machine. The nozzles and the angle and spacing of the bucket are such that there is no end thrust on the shaft and a thrust bearing is therefore dispensed with. A short test on this 3000-kw. machine, with 175 lb. steam pressure, 190° Fahr. superheat and 93 per cent. vacuum, gave a water rate of 13.2 lb. per kilowatt-hour, and the manufacturer has expectations of bettering even this very high economy.

The regulating of this machine is accomplished by the usual type of governor operating a balanced valve so that the steam flows in a steady stream and is throttled in proportion to the load on the turbine. The whole machine is very compact, quiet running, and fully self-contained. The oil pump for supplying oil to the bearings is operated from the turbine itself and the entire unit impresses one as being very simple.

It seems to be the general custom abroad for the turbine manufacturers to supply and install the condensing apparatus. Some of the manufacturers even build the condensers and pumps. Surface condensers are used almost universally and the Edwards type of pump is quite common. The usual practice is to install the condenser underneath the turbine in the basement of the station and place an Edwards type air pump with a motor-drive alongside the condenser. Very good vacuums are obtained with this type of condensing apparatus. Where a very high vacuum is desired, the Parsons Co. has introduced what is called a steam augmenter to accomplish practically the same purpose as would a dry vacuum pump. This augmenter is virtually a steam ejector and uses steam from the turbine to exhaust a portion of the air from the condensed steam space of the condenser. This device has not been in use for any great length of time and it was not possible to get any very accurate data as to its efficiency.

Two turbine installations were seen where, for the purpose of economizing floor space, the surface condenser was installed in a vertical position. In one station, the apparatus has only just been installed and is too new to get any reliable information as to the performance of a vertical condenser. In the other station, the apparatus had been in for a considerably longer period of time and was not giving complete satisfaction. Part of the difficulties, however, were undoubtedly due to other reasons than because the condenser was built with vertical tubes.

Centrifugal pumps are used quite extensively to lift the circulating water from the source of supply and pass it through the condenser.

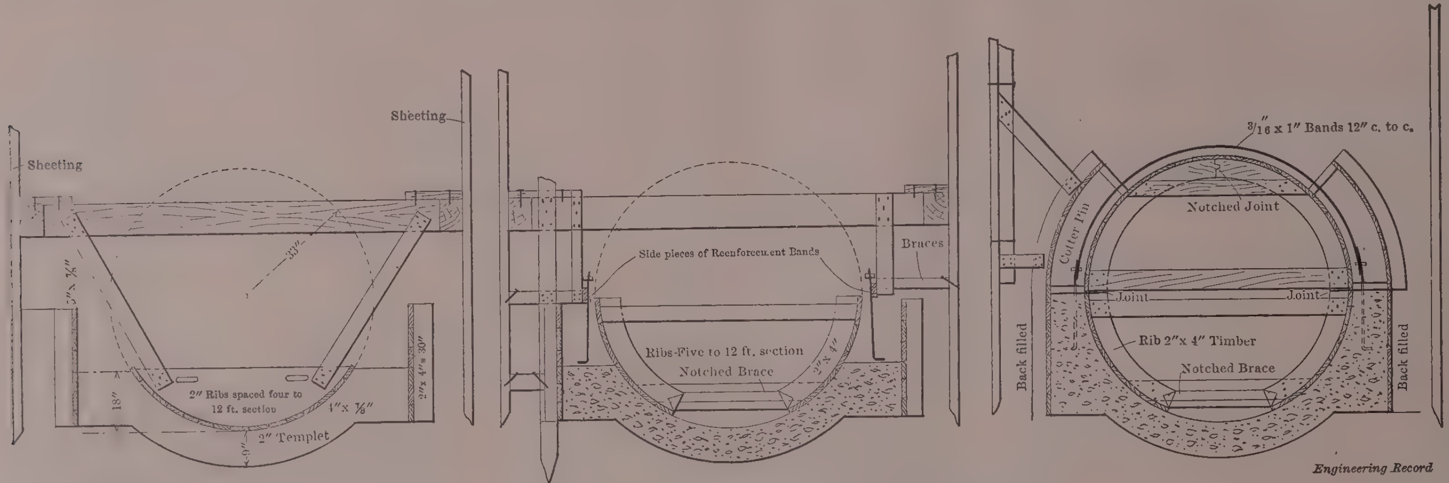
Experiments on Surface Condensation.

In a paper read before the Victorian Institute of Engineers Mr. J. A. Smith gives the results of investigations to determine the effect of the presence of small quantities of air mixed with steam upon the efficiency of condensation. The presence of air in quantities that might in the past have been deemed insignificant, may, in fact, become the factor limiting the efficiency of a whole steam plant. For instance, air equal in pressure to only 1/20 in. by the mercury gauge will at 90° F. reduce thermal transmission some 25 per cent., whilst 3/20 in. will lower it about one-half. The older data and generalizations are inadequate for present practice, which carries the expansion of steam and the temperature of rejection to points not then attempted. Moreover, incomplete investigations of pure steam are not applicable to mixtures of steam and gas. Although his experiments do not deal with any part of the subject finally, he shows that short tubes are thermally more efficient than long tubes, and that the advantage resulting from increasing velocity of flow is a diminishing one, whilst the cost of attaining it rapidly increases. It is probable that the tube length, diameter, temperature differences, and rate of flow will be found to be expressible by a general law; but this he has not yet reached. His chief conclusions are: (*a*) If high vapor vacua are required air must be excluded. (*b*) With high vacua climatic conditions are potent limiting factors, and must be specially considered. (*c*) In the absence of exact knowledge the impossible has been attempted in design. (*d*) Only by rational condenser proportion will it be possible to push the efficient expansion of steam to those limits that recent improvements seem to render easy of attainment.

High-Pressure Gas Distribution is now practiced in the suburbs of Berlin. The gas is put under pressure by two Root blowers at the Mariendorf works. Each blower is able to deliver 7,600 cu. ft. per minute under a pressure of 35.5 in. to the main, which is 5.6 miles long, and 24 to 42 in. in diameter. At each distributing center the gas is taken off through a governor which reduces its pressure to that in the local mains.

Reinforced Concrete Sewer at South Bend.

The sewerage system of South Bend, Ind., is designed to carry the combined domestic-sewage and storm-water flow. South Bend is built along the banks of the St. Joseph River, a stream with a comparatively swift current and a uniform volume of flow, into which the flow from the sewerage system is discharged without purification. The original sewerage system was built to serve that portion of the city that is at present practically all included in the business district. It has an outfall about ½ mile downstream from the center of that district. The city has been extended for some distance, both up and downstream from the business district since the original system was built. In 1892 a 90-in. main outfall sewer, 3,000 ft. long, was built to serve most of the portion of city back of and downstream from the business district. This outfall is built of three rings of common brick laid in cement mortar. Two branches were built from the end of the 90-in. outfall, one an 81-in. sewer, 2,900 ft. long, and the other a 66-in. sewer, 4,400 ft. long. Both of these branches are built with two rings of common brick laid in cement mortar. The 81-in. sewer extends back inland, while the 66-in. sewer extends along back of the business district, generally parallel to the river.



Sections Showing Concrete Forms and Order of Erection.

Shortly after the 66-in. sewer was completed, it was extended for 910 ft. with a sewer having a 49x60-in. oval cross-section, and then for 1,750 ft. with a 48x57-in. oval section, built of a single ring of brick laid in cement mortar. In 1904, this branch of the trunk sewer had to be further extended. As the 48x57-in. oval section built of a single ring of brick in 1893 was still in good repair, the additional extension was built of a single ring of paving brick laid in cement mortar. This recent extension has a 42x54-in. oval section and is 2,850 ft. long.

The 81-in. branch of the main outfall sewer was extended 3,500 ft., in 1905, with a reinforced-concrete sewer. The first 1,670 ft. of this extension was built 72 in. in diameter, and the remaining 1,830 ft. was built 66 in. in diameter. This branch is at present being additionally extended 2,434 ft. with a 66-in. circular section, also built of reinforced concrete.

The soil through which the greater part of the sewerage system has been built is quite sandy and generally has good natural drainage, which may account in part for the manner in which the sewers of comparatively large section have stood, when built of a single ring of brick. The sewer trenches through this sandy soil all have to be closely sheeted, and the sheeting thoroughly braced to prevent the sandy soil from running and caving. The reinforced-concrete extension that is being built to the 81-in. branch is in a trench with an average depth of about 18 ft. The trench is opened up so that a clearance of 1 ft. is provided between the sheeting and each side of the sewer barrel.

The details of the reinforced-concrete sewer that is now being built and the stages in which its construction is carried forward are shown in the accompanying illustrations. The arch of the sewer barrel is reinforced with 3/16x1-in. steel bands. These bands are placed transversely, 12 in. apart on centers, and are 3 in. inside the intrados of the arch, the latter being 9 in. thick. These bands are each in three pieces, a piece on each side extending from 15 in. below to 6 in. above the springing line of the arch, with a piece in the arch joining these two side pieces. The pieces of each band are fastened together by cotter pins and are assembled as the sewer is built.

The sewer is built in 12-ft. lengths for convenience. The bottom of the trench is shaped as nearly as possible to the grade and shape of the base of the sewer. Four braces to each 12-ft. section are then nailed across the trench between the lowest rangers on the sheeting. A partial form consisting of a vertical row of lagging is set up on each of the outside lines of the sewer barrel, as shown in one of the illustrations. Each section of this lagging is braced in position by stakes driven into the bottom of the trench and fastened at the top of the cross braces between the rangers. A template for the invert of the barrel is also suspended from the cross braces, which braces are attached to the four 2-in. ribs of each 12-ft. length of invert template. The concrete is carried up to the top of the template on the sides, after which the template is removed. The side pieces of the reinforcement bands are then set in place on braces attached to the sheeting and cross braces. These braces are arranged in such a manner that the position of the reinforcement cannot be changed as the concrete is placed.

The form for the remainder of inside of the sewer is in four sections. Two of these sections extend up to the springing lines of the arch and are placed as soon as the invert template is removed. They are held in place by a brace nailed to their ribs at the top and by a notched brace which fits into notches in ends of their ribs at the bottom. The concrete is carried up to the springing lines of the arch when this portion of the forming is in place. The two sections of the arch form are then put in place, the remaining piece of each reinforcement band is fastened to the two side pieces and forms are erected for the extrados of the arch up to the 45 deg. lines.

Several lengths of the invert are first built, then the concrete is carried up to the springing lines of the arches on these lengths of invert, after which the arch is built. In this manner, the men erecting the forms and the concrete gang can work without interference. Curves in the sewer are made in chords of the arc, 10 ft. long, an additional fall being provided in the curves to overcome the friction at the angles between the straight chord sections. In this manner a great deal of expensive forming that would otherwise be required on curved sections is avoided.

The excavation is made with a Potter trenching machine. The backfill is made on the sewer barrel with the same machine after the arch of the sewer has been built about a day. The outside forms are removed before the backfill is made, but the inside forms are left in place at least two weeks before they are removed. The inside forms are readily removed by knocking out the bottom cross brace between the two lower sections, when the sections of the arch form will fall down.

The details of the forms are perhaps lighter than those generally used in such work, but they have been perfectly satisfactory in all of the construction of the sewers that has been built. The method of bracing the sections of the forms in place has also been quite satisfactory. The anchorages provided for the reinforcement bars determine their position certainly.

All of the concrete is mixed in a Smith mixer set up on the side of the trench on trucks. The concrete is discharged from the mixer into an open wooden trough leading down to the point where work is in progress. This trough is in sections so its length can be varied to suit the level of the work. The trough is carried by the cross braces of the sheeting. It is rather remarkable to note the manner in which the concrete will flow in this trough when the latter is laid on flat grades. The mixer is moved forward as the work progresses.

Two grades of concrete are used. That in the invert and in the bench walls of the arch is mixed in the proportion of 1 part of cement, 3 parts of sand and 6 parts of bank gravel. The concrete in the arch consists of 1 part cement, 2 parts sand and 4 parts bank gravel. After the sewer barrel is finished, the invert is coated with ½ in. of 1 to 1 cement mortar up to the springing lines of the arch.

The contract price, it may be added, for the reinforced concrete extensions made in 1905, including trench excavation and backfilling, was $9.75 a linear foot for both the 66 and 72-in. sewers. The contract price for the 66-in. sewer now being built is $9.50 a linear foot, also including excavation and backfill.

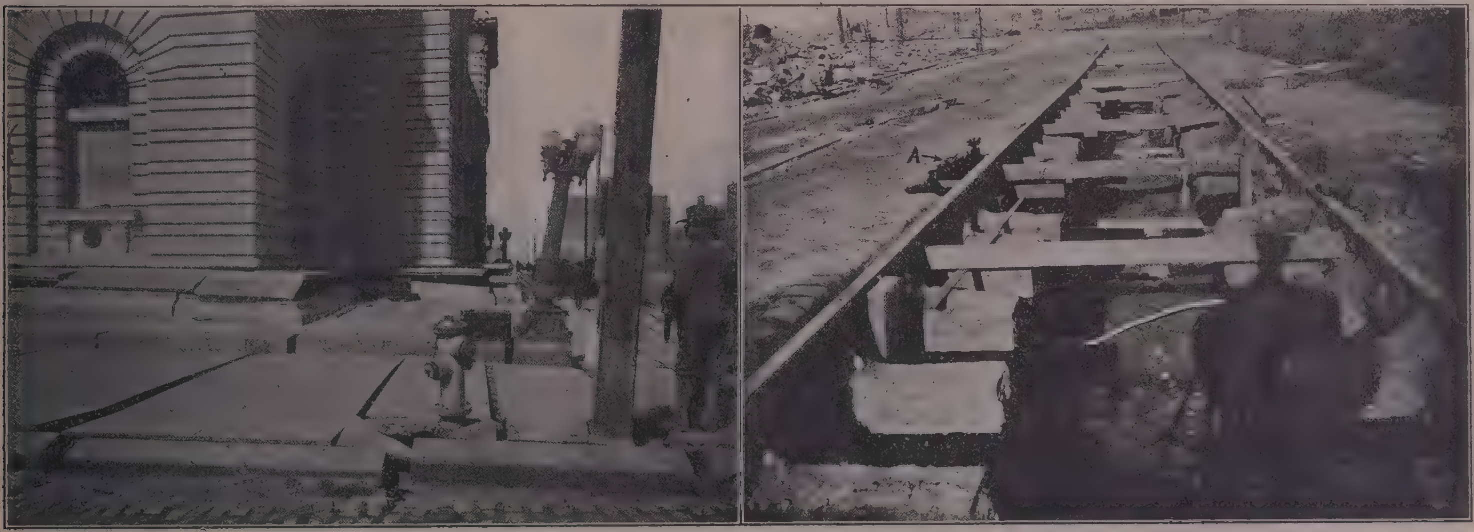
The recent extensions to the sewerage system were designed and built under the direction of Mr. A. J. Hammond, city engineer, of South Bend.

The Structural, Municipal and Sanitary Aspects of the Central Californian Catastrophe—III.

By Charles Gilman Hyde, Assoc. M. Am. Soc. C. E.

Preliminary Conclusions Affecting Building Construction.—The writer firmly believes that the new building laws of San Francisco, and the regulations which might apply to any locality in which earthquakes are liable to occur, should very comprehensively consider the maximum height to which buildings of certain definitely specified types may be constructed. In the writer's judgment even "Class A" buildings should be limited to a height of not more than ten or twelve stories. From an aesthetic point of view, also, this matter is of importance. It is probably true that a more or less uniform "sky-line" along streets otherwise properly constructed and laid out, is more pleasing to the eye than one deeply indented.

It appears self-evident that buildings in whose construction provision is made for safety against the effects of both earthquake and fire cannot be erected at the same cost as that which would be required to provide suitable resistance to meet but one of these conditions alone. This experience is not unusual, and is noted elsewhere in engineering. Thus it is well recognized that a greater expenditure of money is demanded, both for the construction of works and for their maintenance in water purification problems where turbidity and the disease bacteria both require removal, than where only one of these conditions in the raw water must be provided for.



Southwest Corner of U. S. Post Office. **Effect of Broken Sewer on Fourteenth Street.**

The first picture was taken at the corner of Mission and Seventh Sts. The ground is a loose fill and settled considerably, while Mission St. has apparently been thrown to the southeast at this point at least 2 ft. The second picture shows the result of the destruction of a sewer on Fourteenth St., near Howard St. The crown of the sewer was broken in, the surface material washed in, as at A, and the sewer so completely filled with sand as to back up the sewage, as at B, above the elevation of the crown.

No one thing has been more clearly demonstrated by the fearful havoc wrought by the earthquake and fire in San Francisco, than that the building laws applying to constructions within such regions should be entirely revised and their provisions strongly enforced. These regulations should not be the work of any one man or of any one set of men, but should be the result of the painstaking consideration of authorities upon these matters, in co-operation with prominent men of affairs.

Foundations.—Wherever soft material exists, the foundations must be carried on piles driven to the point of firm bearing. In the case of important structures, these piles might well be capped with some reinforcable material, like concrete, and thus held rigidly in position. Where harder soils exist, foundations should be carefully bedded and should be so bonded as to form more or less perfect monoliths. They should have such an area of bearing surface that the rapid oscillation of the earth and of the structures supported by the foundations in question should not produce local settlement.

Steel Framing.—It appears evident that no important high structure should be built in the future in this region, without a complete frame of steel or some system of reinforced material, perhaps concrete, employed under rigid provisions of well-considered building laws. The steel girders should in all cases be rigidly riveted to the columns and should be stiffened by knee-braces or other similar devices. In order to produce sufficient vertical stiffness, the columns should be broken at the floor lines alternately. Vertical bracing between columns and horizontal bracing on floor lines should manifestly be provided to a far greater extent than in Eastern structures of this sort. Moreover, it seems especially important that the entire outer shell of masonry should be supported wholly by the steelwork, to which it should be much more firmly anchored than is the case with most if not all structures of this type now in San Francisco. This exterior masonry should be comparatively light; it should be independently fixed to the framing in such a manner that it may be removable between floors without destroying the integrity of the work above or below them. It is clearly not sufficient for the masonry to rest on the outer girders at the floor lines, but vertical and horizontal members should be provided to afford sufficient anchorage and lateral stiffness to all exterior walls.

In the future, the very greatest care should be exercised in protecting the steelwork everywhere from the direct action of fire, and there seems to be no better method than that which comprehends surrounding the members in question with dead air spaces, one or more. These may be constructed of metal lath, securely fastened to the steel work, and thickly plastered with the best Portland cement mortar employing, perhaps, crushed cinders or slag in preference to sand. In cases where inflammable materials capable of very rapid combustion are stored in such buildings, the steelwork should be the more safely protected by simply adding to the number of dead air spaces surrounding the various members. The practical engineer will at once recognize the fact that this proceeding will cost money, and in every case the question of risk will probably require to be carefully studied, and that procedure which will give the maximum relative economy should be selected, providing the indicated construction does not interfere with the provisions of the building laws applying to the locality under consideration.

Masonry Walls.—The effect produced by earthquake and fire in the devastated district of San Francisco demonstrated very clearly that brick or other masonry walls in tall and important buildings have little excuse for existence unless they are very thick and thoroughly reinforced vertically and horizontally with metal so disposed that it becomes an integral part of the interior construction, which in form should be carefully designed to furnish adequate lateral support to such walls. This feature of building construction is one which seems to have been greatly overlooked in San Francisco, and very many instances exist where structures have been ruined by earthquake because the outer walls were not properly reinforced and were not laterally stayed. It is evident that this condition is difficult to secure in the case of high buildings without a complete steel frame of the general type already described.

Interior Walls and Partitions.—These should manifestly be of such construction that they cannot be overthrown by the vibrations and shocks caused by earthquakes. In this respect, hollow tiles—in other regions efficient—have proved deficient in stiffness and have been very generally thrown down, thus admitting of far greater devastation by fire than might otherwise have occurred, or, better, would have occurred if interior fires alone could be considered. Where steel frames or reinforced concrete interiors are provided, there does not appear to be a safer or more satisfactory protection than that involving the use of heavy metal lath, firmly secured to small channels or I-beams, which in turn are firmly anchored to floors and ceilings. The covering of this lathing with a thick layer of the best Portland cement mortar would appear to furnish a protection as satisfactory in case of fire as that secured with the use of any other materials now on the market, and from the standpoint of stiffness this construction would probably be entirely satisfactory.

Terra Cotta Blocks.—The use of terra cotta blocks in floors and in interior walls, for ornamental purposes or for window lintels, sills, etc., in exterior walls, or used as the principal facing material on these walls, unfortunately in San

Francisco proved most unsatisfactory both with respect to resistance to the effect of the earthquake and to the heat produced by the fire. The writer knows of no better illustration of the effect of earthquake upon this class of material, than the north wall of the Fairmount Hotel, previously described, where the vibrations have caused very serious destruction of the terra cotta hollow blocks of which the exterior walls of this famous building are so largely constructed.

Granite.—It has always been recognized that granite is a very unsatisfactory material in case of fire, inasmuch as it spalls seriously under the action of comparatively slight heat. In many instances in San Francisco granite base courses and footings of important structures even other than Class A were used and miserably failed on account of the destructive effect of the fire. Unless attached and suitably anchored to the steelwork, as already described, the writer believes that this material should not generally be used. It may, however, be employed in some cases where external and internal fires are reasonably certain to be very infrequent, if not impossible, on account of the character of the buildings in the vicinity of the structure in question. In no case, in the writer's opinion, should this material, or sandstone, or marble, be used in large masses, in very high and important structures independently of the steel work; in other words, elsewhere than in Class A buildings. It appears to have been clearly shown that great loads should not be centralized on masonry columns of the materials just mentioned.

Settlement on Sixth Street.

Disruption of Valencia Street.

The first picture was taken on Sixth St., just south of Howard St. The amount of the drop at the lamp post where the men are standing was fully 2 ft. The sidewalk north of this point and the street at the junction of Howard appears to have settled but very little. The disruption of the street surface shown in the second picture was caused by the explosion of a large gas main.

Sandstone.—In general it may be said that sandstone proved to be far more satisfactory than granite in fire-resisting qualities. Nevertheless, almost everywhere throughout the burned city, exterior surfaces of sandstone have been seriously injured by the fire. One of the most important examples of the spalling of this material by fires of no great intensity is found upon the Kohl building.

Brickwork.—Brickwork employing hard-burned or hard-pressed brick seems to have been more satisfactory in its fire-resisting qualities than any of the materials immediately foregoing.

Mortar.—It is evident that the use of lime mortar should be entirely discouraged in all masonry construction of the future within the region under consideration. In many cases coming under the writer's observation brick walls unexposed to fire were found to have practically no tensile strength; hardly as much as would have been secured by the use of well-selected and well-tempered clay. Such masonry was destroyed by the earthquake and in its destruction caused very considerable loss of life. Had the earthquake occurred at a less fortunate time, this poorly constructed masonry would have been responsible for a far larger number of deaths.

In structures of all sorts, properly designed and executed, masonry employing Portland cement mortar was found to have withstood the force of the vibrations reasonably well.

Reinforced Concrete.—Without question reinforced concrete should have a very definite and important place in the construction of the new San Francisco. It seems clear that for certain types of buildings there can be no more suitable element of construction; but it must be recognized that more detailed information is needed with respect to this material by the ordinary architect, builder and engineer. There are many structures in the United States which appear to have been built upon exceedingly dangerous lines, involving the use of unreliable formulas and a lack of comprehension of the details of the real problem. It is a notable fact that the use of reinforced concrete was not allowed in San Francisco, except for floors, owing to the relentless antagonism of the trades unions. The reason for this action on their part is apparent; it is not a credit to the authorities, however, that such a state of affairs could have existed.

It is gratifying to observe in this connection, that reinforced concrete floors, employed in several important buildings in San Francisco which have survived the earthquake and fire, appear to be practically uninjured and in an entirely satisfactory condition for further use with heavy loads. More extended investigation may modify this statement in degree, but it is believed that it very closely indicates the actual facts.

The new building laws in San Francisco should in some way control the use of reinforced concrete and should very definitely fix the height of the buildings, the amount and disposition of reinforcement, the method and amount of protection of the reinforcing material from the action of direct heat, etc. Moreover, the regulations might well specify the number of fully reinforced cross-walls which should be provided for the double purpose of affording suitable lateral support for the exterior walls, and for confining internal fires.

As already suggested under the caption "Foundations," it would appear that reinforced concrete has a very distinctive usefulness in this field.

Ornamentation.—Unstable ornamentation of all sorts should be avoided in the construction of buildings in regions subject to earthquakes. Throughout the devastated district in San Francisco, great blocks, stone spheres of masonry, carved figures, etc., were thrown to the ground by the force of the oscillations, and had the temblor occurred at a time when the streets were crowded with people, it is safe to assume that great numbers of lives would have been sacrificed, due to this source alone.

Fire Walls and Parapets.—There is a very large class of cheap buildings having exterior walls of brick or other masonry which are provided for architectural and other reasons with "fire walls" or parapets. These walls extend above the gutter line of the roof, and are nearly always unsupported laterally. Throughout the region affected by the recent earthquake, not only in San Francisco but in every community where this type of building prevails for business purposes these walls were thrown down. This fact offers an excuse for once more drawing attention to the fact that a terrific destruction of life would have been occasioned by the falling of these walls and other unstable constructions had the earthquake occurred when the streets were crowded with people.

Cornices.—For the same reasons which have been stated as applying to heavy ornamentations and to fire walls and parapets, it is very evident that cornices should everywhere be constructed of very light material, which should be anchored in a firm manner to metal supports forming a part of the steel or other framing of the structure. In no case should heavy projecting masonry be used for cornice work, no matter how apparently well anchored it may be.

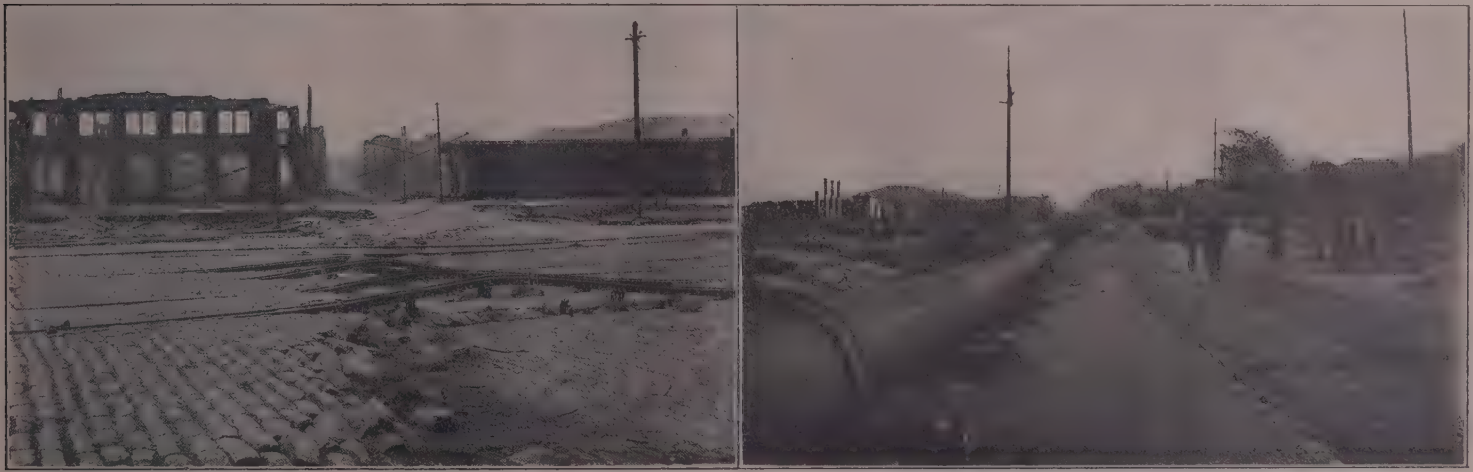
Screens, Shutters and Doors.—The use of screens, shutters, and interior and exterior fireproof doors should be very generally insisted upon in the reconstruction of San Francisco. For the finer types of buildings, the writer knows of no more efficient screen than some sort of rolling metal blind, comprised within the upper portion of metal window frames. These shutters or screens should be "unbalanced" and should be held in position with some sort of fusible plug which would allow them to fall when the temperature rises to, say, 150° Fahrenheit, a degree of heat which, it will be recognized, is too slight to produce warping of the frame and consequently a failure to operate. For factory buildings, heavy metal-hinged shutters and doors, constructed with dead air spaces, without any wood whatever between the exterior and interior faces, might well be used in connection with heavy metal frames and jambs.

Wire Glass.—In mill and warehouse construction, in basements and skylights, it appears very certain that glass reinforced with metal, such as the well-known "wire glass," is of distinct value.

Of course, this should be installed in properly constructed metal frames, arranged to close automatically should they be open for any cause at the time when the internal or external temperature reaches, say, 150° to 200° F. Probably no more important example of the use of "wire glass" in this manner is to be found than in the California Electrical Works building, already described.

Protection of the people upon the sidewalks from falling glass broken during severe oscillations caused by earthquakes might well be carefully studied. One solution of the problem might be the attachment of a wire screen of perhaps four meshes to the linear inch to the outside of all window frames. This screening might be arranged to be removable for occasionally cleaning the windows.

Metal Window and Door Frames.—As already pointed out, no building can be considered protected from fire, internal or external, which has not been provided with window and door frames of metal. In the case of windows, an arrangement can readily be perfected whereby the frames may include unbalanced rolling shutters, or blinds, similar in pattern to the well-known "venetian blind," which will drop at a certain prescribed temperature. These screens are fully as valuable in protecting outer masonry from internal fires, as in protecting internal construction from flames originating without the building.



Tracks at East and Pacific Streets. **Temporary Main on Valencia Street.**

The first picture shows the distortion of car tracks and the line of the local fault in East St. at its junction with Pacific St., along the water front. This territory is within the area of made land on the marshes of the old harbor front. The second picture shows a 24-in. cast-iron pipe line hastily placed in Valencia St. to provide water for the higher districts, whose supply had been cut off by the destruction of the mains in this street between Eighteenth and Nineteenth Sts. A 16-in. pipe to supply the lower downtown districts was also placed here in an incredibly short time.

Oscillation in Steel Structures.—It has occurred to the writer that a scientific study of the oscillations in tall buildings of different types and of different methods of construction might be made with results which would be of the greatest engineering value. Such an investigation would comprehend the use of specially designed instruments which would be located at different heights in the structures in question, as for instance just above the foundation, at the top, and at intermediate points. These instruments could perhaps be designed to register the vibrations produced by heavy winds as well as those due to earthquakes.

Chimneys.—House chimneys should be classified, of course, as masonry structures and the same general conclusions already reached should be applied to these. It is very evident that lime mortar with its unsatisfactory and inefficient bond should not be used in their construction. In fact, in view of their well-nigh universal destruction in the region affected by the earthquake, the writer is inclined to believe that reinforced concrete surrounding the usual tile flues might well be used pretty generally in chimney construction. Perhaps the same results could be secured with the use of brick carefully reinforced vertically.

In industrial plants, it is probably true that where important power installations are involved, the use of comparatively small and low chimneys with forced draft will comprehend the condition of greatest safety as well as greatest economy. Where massive tall chimneys are absolutely required, as for instance for the purpose of conveying destructive and dangerous fumes into the higher atmosphere, reinforced concrete, properly lined with fire brick, will no doubt have its place. Perhaps brickwork can be used with satisfaction if it is strongly reinforced by vertical rods and internal or external horizontal bands. The vertical rods might properly have large plates securely fastened to them at intervals to carry the vertical stresses and to distribute them in the brickwork.

The Street Problem.—The effect of earthquake was very marked in San Francisco wherever filled ground existed. The original shore line was far different from that of to-day and passed around the easterly base of Telegraph Hill to the southerly end of Montgomery Avenue, thence southeasterly to Market Street at Battery Street, thence to Russian Point, thence around the old Mission Bay. All of the land now lying east of this broken line has been recovered from the sea by filling on the marshes and tidal lands.

Earthquake Effects.—Within this filled district, the vibrations of the earthquake caused a general but irregular settlement. The streets naturally followed the changes in elevation and a wave-like effect was produced. Observations on Market, Mission, East and other streets frequently indicate an amplitude of wave height of two feet, while occasional places are found with greater differences in elevation. In the Mission district, and in certain other parts of San Francisco, as, for instance, along the courses of former tidal streams, large areas of filled land exist. In such cases, the effect produced by the earthquake was not generally in the form of waves, as already described, for the eastern portion of the city was basin-like, representing local settlement in the streets and adjacent areas, and in some cases, decided misalignment. The most important wave-like distortions were observed on lower Market and Mission Sts., and on East St. along the present water front. The most important local settlements and transverse movements occurred in the vicinity of the Valencia Hotel between 18th and 19th Sts., on Valencia St., on Howard St. between 17th and 18th; on 14th, between Mission and Howard; on Folsom, at the corner of 17th; on Mission, at the corner of 7th, and on Van Ness Ave., between Vallejo and Green Sts. Where the ground was hilly and solid, it was not decidedly affected by the earthquake shock. The distortion of the streets evidently has no relation to the character and nature of the artificial surface. For, of whatever construction this may have been, it is very evident that the street surface would follow the profile and alignment of the ground upon which it rested. It is not at this writing known how general are the changes in alignment produced by the earthquake. It is needless to say that the entire situation must be gone over very carefully in order to prevent misunderstanding and consequent legal difficulties.

The most important and interesting case of settlement and throwing out of alignment of streets in San Francisco, due to the vibrations of the temblor, was that of Valencia St., between 18th and 19th Sts., in the Old Mission district. At this point there was formerly a tidal stream, known as Mission Creek, whose existence had long since ceased owing to the fact that its course had been filled in and the land so reclaimed had become thickly built up. The earthquake caused a settlement of from 6 to 8 ft. for a distance of from 150 to 200 ft. along this street, and at the same time shifted the entire street, with adjacent lands, eastward through a maximum distance of 9 to 10 ft. This change in alignment and grade could, of course, mean nothing less than the entire destruction of all water and gas mains, electric lighting and telephone conduits, sewers, cable conduits, railroad tracks, etc. The breakage of these important lines, especially to the water mains, was of greatest significance. In this case the destruction of the water pipes, of which a 28-in. and a 16-in. were found in this street at this point, meant the cutting off of a large part of the water supply of the portion of the city which was soon to be in flames.

In certain country districts, a very decided throwing of highways was produced in some cases. For instance, in the vicinity of Inverness, in Marin County, Mr. Gilbert, of the U. S. Geological Survey, reports that a highway had been sheared by the fault already described, and the two ends, instead of being in line, are now 20 ft. apart on centers.

Fire Effects.—The effects of fire on stone block pavements was very pronounced in many places. Generally the surface, only, was affected, and was indicated by the slightly spalled condition. In some cases, however, as for instance on Howard St., between 12th and 13th Sts., the heat was so intense and the blocks were of such a nature that in some places they were wholly destroyed. Granite curbs, wherever existing, exposed to the action of the fire, were invariably very seriously spalled, and in some cases, absolutely ruined. Asphalt pavements in the vicinity of hot fires, principally in or near the gutters, were very generally destroyed, being burned to a brittle powder without any cementing quality whatever. It is probable that the concrete upon which these pavements rested, however, was uninjured, and it is also very certain that the injury to the asphalt surface itself did not ordinarily extend many feet toward the center of the street from the gutter line. The troweled surfaces of concrete sidewalks was very generally chipped and broken in the neighborhood of hot fires.

General Observations.—San Francisco very greatly needs a complete and comprehensive readjustment of streets to accommodate the now greatly congested traffic, to offer better protection against fire, and to furnish more adequate opportunities for the location, in a strategic manner, of the important conduits for water, gas, electricity (in lighting, telephone and telegraph service) and for sewage. Such a scheme is probably embraced satisfactorily in the well known Burnham plans for the beautification and improvement of the city. These plans were prepared about two years ago by Mr. Daniel H. Burnham, of Chicago, in response to the request of the Association for the Improvement and Adornment of San Francisco.

Mr. Burnham's plans, moreover, contemplate the creation of parks and playgrounds in the densely populated districts. Sanitarians have long recognized the potential value of such municipal features. It had been expected that these could only be obtained at an enormous cost by the purchase of the required lands under condemnation proceedings and the removal or destruction of buildings thereon. Now, however, a golden opportunity has evidently arrived. Over a very extended tract all structures have been completely removed by the combined effect of earthquake and fire, so that the legal aspect of the problem of acquirement must be very much simplified on this account. Other cities like New York and Boston have obtained their playgrounds and "breathing places" at a very great expense, after surmounting, and only after surmounting, very trying legal difficulties. Great boulevards like that proposed for Philadelphia have been projected, laid out and acquired only in the face of even greater difficulties and obstacles. How great, then, is the present opportunity of San Francisco and how important it is that these municipal requirements shall find their proper place in the new city.

The effect of the settlement of streets, in districts where filled ground exists, upon the various pipes and conduits underneath them, will be referred to mainly in connection with the water supply and sewerage problems.

Attention might well be called to the destruction of gas mains during the fire, owing to the fact that these were badly shattered by the earthquake in certain places, probably for the most part where they passed from soft to firm ground and vice versa. It is possible to believe that some explosions of gas occurred due to the heat of the fire itself. Many of the explosions produced serious destruction of the streets in their vicinity, and probably wrecked large water pipes, sewers, etc., which would otherwise have been uninjured.

Attention should also be directed to the condition of the cable railway slots in many parts of the city, due to the earthquake or fire, or to their combined influences. For long distances, the guide bars forming the sides of the cable slots have been forced together, sometimes tightly, sometimes only slightly; in either case, with disastrous effect. These guide bars are held by steel frames of I or channel sections, bent into horse-shoe shape. These were embedded in concrete and placed at short intervals along the track. The distortion and closing of the slot is observable on streets where the effect of the earthquake upon the tracks and other highway structures is inappreciable. It is probably reasonable to assume that this unfortunate condition so generally produced was due to the very high temperature maintained for a considerable period in the region affected. This would naturally have the effect of forcing the ends of the horse-shoe frames together. Upon cooling the ends did not again separate, either because the material did not retain its resilience, or because it was impossible to resume its original position owing to the fact that the pavement also expanded and held the slot in its new place. In either case, the remedy is not clear to the writer at the present moment. The whole subject will be investigated by the sub-committee on Lighting and Transportation of the San Francisco Association of the American Society of Civil Engineers.

The writer knows of no municipal catastrophe which has pointed out more clearly than this of San Francisco and other Bay cities, the absolute necessity of placing beneath the surface of the streets all wires, including those carrying power for transportation systems. This matter is the more important in localities subject to earthquakes, whether frequent or infrequent, whether severe or not severe. This procedure is demanded by every standpoint except that of first cost. Public safety, municipal aesthetics and every argument of science require that the streets shall not carry an unsightly burden of poles and wires, potent with death-dealing possibilities. If this is not done, and if the buildings of a community are not safe, where shall the people turn for safety in the event of future earthquakes like that which has just occurred? Surely there could be no recourse to the streets, for these would be one mighty tangle of wires, every one of which might be capable of dealing death to the unwary. Moreover, it has almost everywhere been demonstrated that such wires are the cause of the most disastrous fires known in the history of the average municipality of to-day. Who can tell how many of the 57 alarms for fire, "rung-in" during the first thirty minutes succeeding the earthquake, were due to this cause? It is evident that a large proportion was not due to injured chimneys, because the hour was too early for household fires to have been generally started.

It is stated that the salvation of the city of Oakland from fire was due to the destruction by the earthquake of the high chimney of the electric power station. In falling, the debris caught the cables and severed them, cutting off the current from the city. At the corner of 14th St. and Broadway the tangle of fallen wires is said to have been such that the street was rendered temporarily impassable. This is in all probability but one of a hundred instances of similar conditions produced in the cities of the territory affected by the earthquake.

There is some question in the writer's mind whether it may not be desirable to construct in such great thoroughfares as Market St. a single large conduit in which, or in compartments of which, sewers, water and gas pipes, cables and electric wires of every description shall be placed, and be so disposed that considerable distortion of the main conduit shall not produce rupture in the pipes, etc. Such a conduit might properly include a subway like the famous examples in Boston, New York, Philadelphia, Vienna and elsewhere.

The street cleaning problem has now become one of very serious difficulty. The prevalence of high winds and the presence of great clouds of dust resulting from the destruction and tearing down of the old buildings and the erection of the new will creat difficulties which for several years will require especially vigilant study and wise methods of procedure. The sanitary significance of dust is too well understood to warrant more than a mention at this time.

The Sewerage Problem.—The construction and maintenance of sewers in certain parts of San Francisco where filled land exists has always presented a difficult problem. As an example it may be said that in 1903, when the Sixth St. sewer, between Howard and Folsom Sts. was reconstructed, it was found that the former sewer had settled from 6 to 9 ft. during the twenty years of its existence. The distortion was ultimately such as to cause failure of the crown in certain places.

As the result of the earthquake, however, many of the effects which had been produced very slowly before, were caused at once with very serious consequences. Brick sewers, the usual type for the larger conduits, were in many places distorted, their crowns were broken and their earth covering was carried into them, causing almost complete stoppage in some cases.

The more important breaks in main sewers observed by the writer may be described as follows:

On Fifth St., between Folsom and Harrison Sts., the brick sewer settled with the adjacent land, its crown was destroyed and the channel had become filled with sand which blocked up the sewage to a dangerous extent.

On 14th St., between Mission and Howard Sts., practically the same effects were produced. The crown was broken in many places and sand from the street filled the channel to such an extent that sewage was backed up above the original crown line. These breaks were indicated on the surface by great holes where all the covering, including the stone block paving, had settled down into the sewer.

On Howard St., at the corner of 17th St., very complete destruction of the brick sewer, as well as most other pipes and conduits in the ground, was caused by the extensive settlements in this region. On Valencia St., near 18th St., similar ruptures were produced.

The cases which have been cited are probably typical of many others occurring in all parts of the city where "made" or soft surface materials exist. It is understood that many of the lateral sewers and house connections throughout the city were destroyed. It is evident that the entire system will eventually require inspection and painstaking repairs. Much careful attention must be given to this matter by engineers of experience with a view to developing the best methods of constructing less destructible sewers in the future. It will be very easy to find a material far better and more durable than brick, but whether this or others would be permitted in San Francisco on account of the influence of the trades unions is a matter which the future only can discover. Reinforced concrete is manifestly better adapted to meet the conditions which have been described as having prevailed in the past and will be likely to obtain in the future in San Francisco. But this type of construction should not be adopted blindly, especially for those locations where sewers pass from firm to soft materials and vice versa.

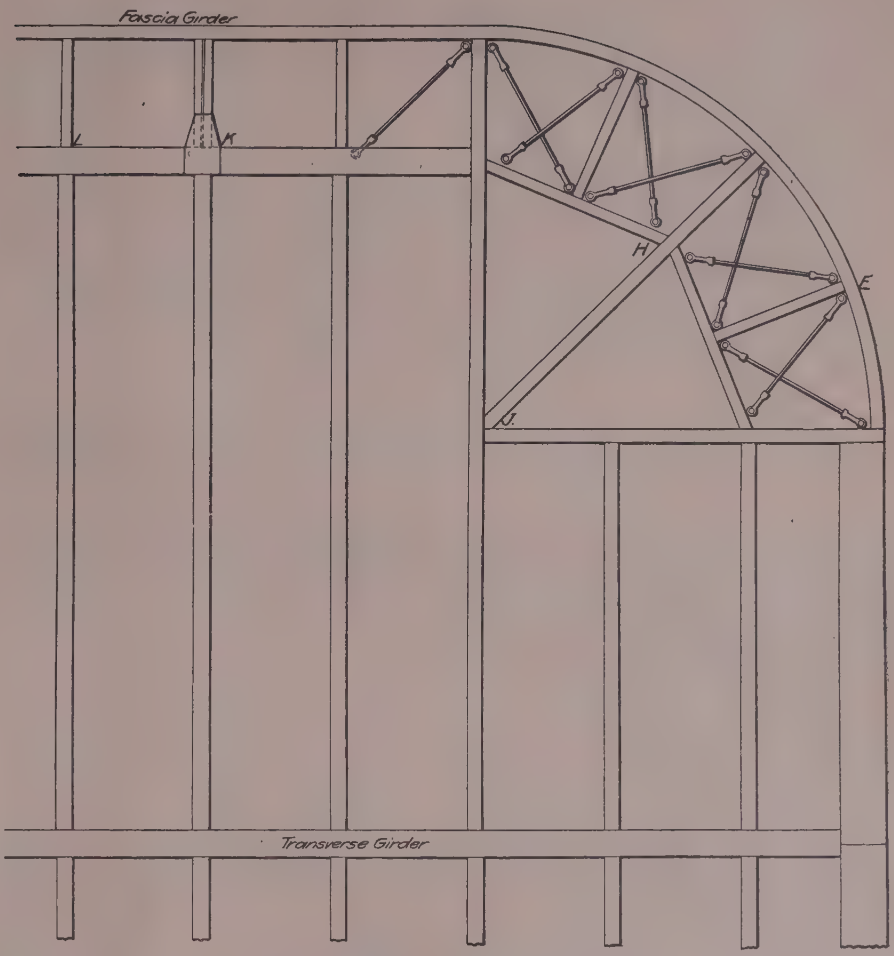
The cutting off for a short while of the water supply of the entire city and for a longer period the supply of certain districts gave rise to temporary sewerage problems which were very difficult to solve. Most of the water closets, if used at all, had to be flushed with water brought in pails, frequently from wells or other sources at considerable distance. The regulations of the Board of Health were very explicit on this point and serious consequences were probably avoided by the observance of the rules which were prescribed.

(To be Continued.)

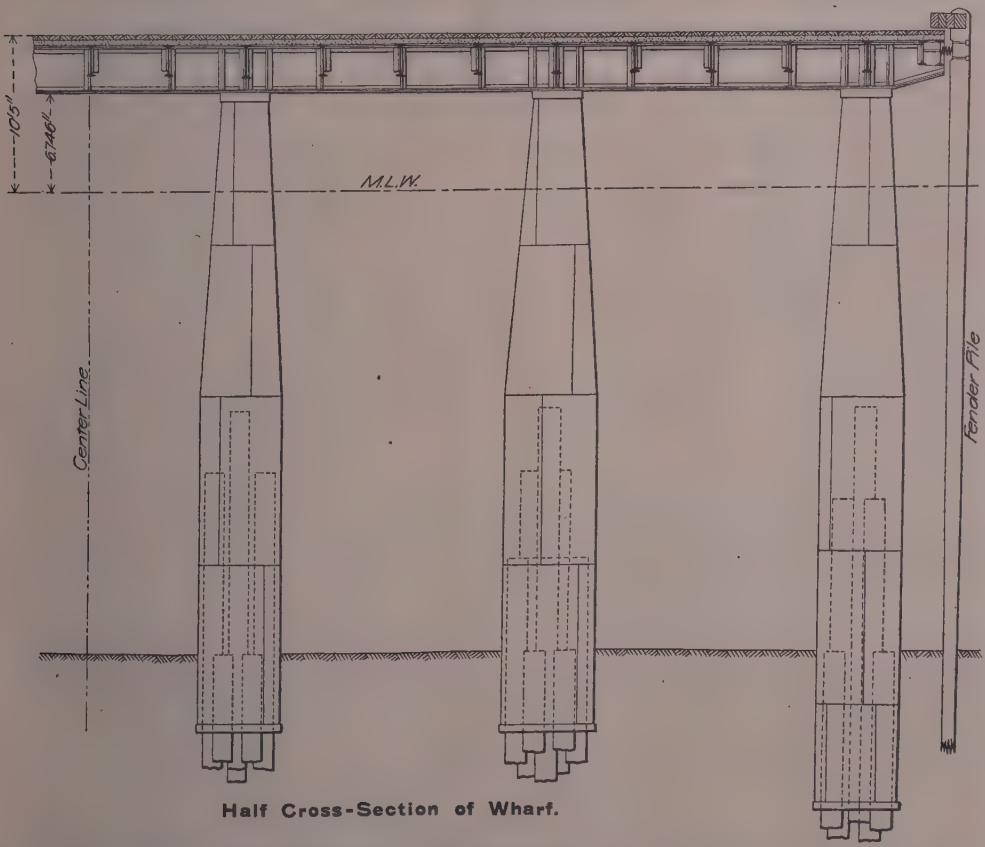
Steel Wharves at Manila.

The United States Government has recently received bids for the construction of two steel wharves at Manila, one to be 110 ft. wide and 650 ft. long and the other 70 ft. wide and 600 ft. long. Both of them have platforms of steel beams and girders carrying reinforced concrete floor slabs and supported by rows of small reinforced concrete piers with steel shells and pile foundations. The principal quantities involved in the contract include about 3,024,000 lb. of structural steel, 262 cylinder piers, 67,000 ft. of timber, 1,595 cu. yd. of deck concrete, 12,400 sq. yd. of wooden block pavement and 328 fender piles.

Wharf A, the larger one, has 25 transverse rows of six piers each. The rows are 25 ft. apart and the piers are 20 ft. apart in the rows. At the outer corner additional piers are placed to provide for impact and conform to the curved superstructure. At the inner end the first row of piers is about 45 ft. from the face of a concrete sea wall with which the platform is connected by longitudinal plate girders. Wharf B, which is only 70 ft. wide over all, corresponds in general to Wharf A, except that there are only four piers in each of the regular transverse rows.



Plan of Outer Corner of Wharf.



Half Cross-Section of Wharf.

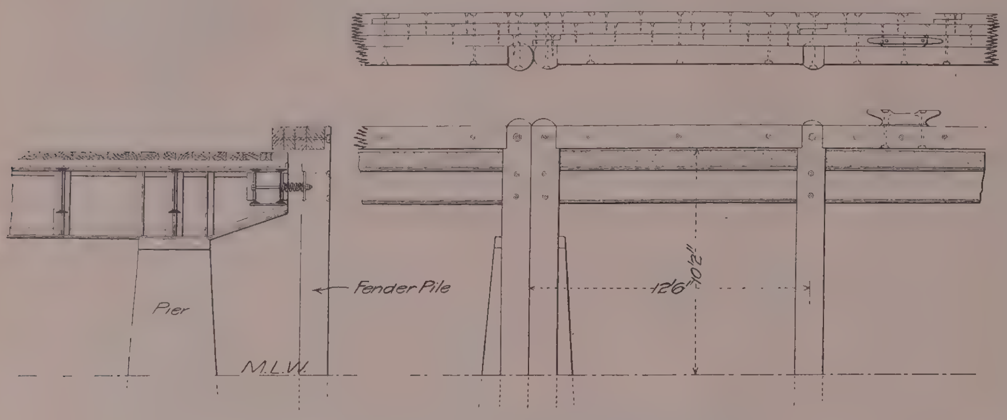
The standard piers rest on five to seven piles from 65 to 75 ft. in length and from 15 to 17 in. in diameter at the butt. Within ten days after each cluster of piles has been driven it is to be enclosed by a cylinder of steel plates from 3/16 to 5/16 in. thick, according to the diameter. The mud is to be pumped out of the cylinder to within 18 in. of the lower edge and the cylinder filled to within 21 ft. of the upper edge with 1:2:4 Portland cement concrete. Four 1-in. corrugated or twisted vertical steel bars 4 ft. long will be imbedded 2 ft. in the concrete, and after the latter has set 12 hr., the cylinder will be pumped dry and a reinforcement frame made of ¾-in. twisted or corrugated steel bars bolted to three 1x⅝-in. horizontal spacing rings will be put in position. This framework will have one rod for each pile in the foundation and will be bedded in 1:2½:5 concrete except for the upper 2 ft., where the concrete will be made 1:1:2.

The row of piers nearest the shore will be capped by a line of plate girders 46¼ in. deep made of two 45-ft. end sections and one 20-ft. middle section, all resting on the finished surfaces of the concrete piers. Their ends abut on the center lines of the piers where they are connected by field-driven rivets through vertical web-stiffener angles. The intermediate rows of piles are capped with plate girders 36 in. deep, made with similar lengths and connections. All of them have cantilever ends projecting 5 ft. beyond the centers of the outside piers. These girders are web-connected to 24-in., 80-lb., longitudinal I-beams 5 ft. apart in the regular panels. In the panel at the shore end there are longitudinal plate girders supported by the abutment and the 46-in. transverse girder, which carry transverse 10-in., 25-lb. I-beams 5 ft. apart.

The ends of the main transverse girders are connected by box girders 25 ft. long, each made of a pair of 18-in., 85-lb. I-beams and a 20x½-in. top and bottom cover plate. At panel points and in the middle of each panel, the box girder is provided with a heavy horizontal triple-spiral car spring projecting beyond the outer face and connected to a fender pile so as to absorb the shock of any impact against the latter. The tops of the fender piles are bolted to a 28x12-in. waling piece built up of a 10x12-in. chock and three 6x12-in. timbers spiked and bolted to it with staggered lap joints. The lower edge of the waling is about 1 in. clear of the wharf deck and moves back and forth over it when the spiral springs are displaced. The springs, 12 in. long, are each composed of an outer 1-in. coil, an intermediate ¾-in. coil, and an inside ½-in. coil centered on a 1⅜-in. bolt that passes through both webs of the longitudinal girder and has a 1-in. bearing plate at the outer end, clamped to the pile.

The outer corners of the wharf are rounded to a radius of about 15 ft. and the 18-in. I-beam fascia girders, bracketed out from the transverse girders, and are braced with diagonal girders and tie rods as indicated in the detail of the plan. All of the girders intersecting at right angles are web-connected with pairs of vertical angles shop-riveted to one member and field-riveted to the other, and all horizontal diagonal rods in the panels between them are 1⅛ in. round, upset to 1½ in., and connected with standard clevises to plates riveted to the lower flanges of the girders. Where the girders make oblique intersections they are web-connected with bent angles and bent plates.

Special eight-pile piers are placed near the centers of the outer corner panels, and intermediate three-pile piers are placed between the regular piers in the rounded corners of the wharf. These piers are braced together in vertical planes by 2-in. round diagonal rods with sleeve-nut adjustments and loop eyes which engage corresponding eyes in short lengths of rods passing through the steel pier shells and imbedded in the concrete with nuts and bearing washers to provide anchorage reaction there.

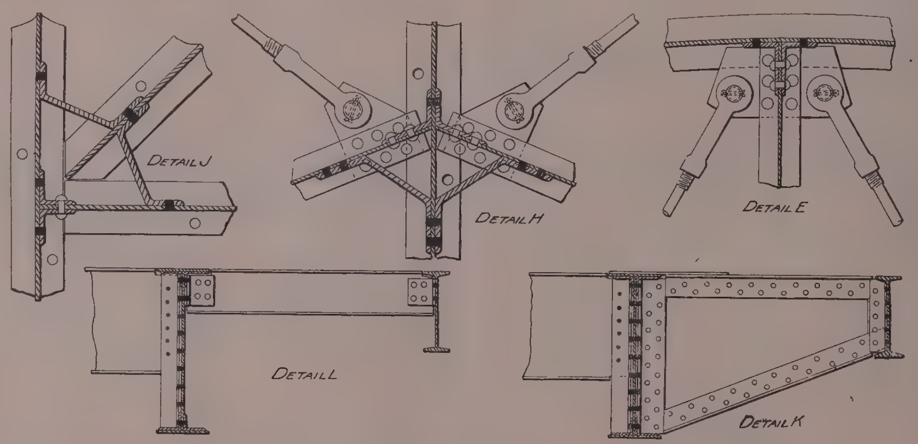


Fenders and Spring Buffer of Manila Wharf.

The concrete floor slab is divided into 15x25-ft. rectangles by lines on the centers of the transverse and longitudinal girders. The moulds are to be thoroughly wet and covered with ¾ in. of wet concrete, on which will be placed a layer of 3-in. mesh, No. 10 gauge, 5/16-in. strand expanded metal or other steel reinforcement of equal strength. This must be tamped ¼ in. below the surface and the mould filled with 1:2½:5 Portland cement concrete to a total depth of 4½ in., thoroughly rammed to grade and floated to the required surface. Not more than 2½ hours after a section is finished it must be covered with 2 in. of damp sand and the latter must be kept wet for ten days. All concrete is to be machine mixed and instead of sand there will be used ground stone screened through a ¼-in. mesh and not containing more than 12 per cent. dust or material passing a 1/50-in. screen. The stone in the deck concrete must be screened through a 1-in. mesh and that in the piers must be screened through a 1½-in. mesh. After the deck concrete is 40 days old it will be well coated with asphalt filler and paved with 3x9x4-in. creosoted wood paving blocks laid with the fibre vertical and the longest dimension transverse to the wharf.

The work is under the charge of Lieut.-Col. W. L. Fisk, Corps of Engineers, U. S. A., director of port works, Philippine Islands. The contract has been let to the Atlantic, Gulf & Pacific Co., of New York. The drawings of the wharf and details were made by Mr. H. C. De Lano, assistant engineer.

State Highway Maintenance in New York must be conducted under the direction of the State Engineer, according to a ruling recently made by the attorney-general. He states that under the law the State Engineer is the sole judge concerning the method and manner of maintenance and is authorized to do the work as he considers best. He may contract with a town or county for the maintenance, contract with private parties, or do the work himself.



Connections of Horizontal Braces and Girders at Corner of Manila Wharf.

A British Investigation of Reinforced Concrete.

Statement issued by a Joint Committee representing the Royal Institute of British Architects, the District Surveyors' Association, the Institute of Builders, the Association of Municipal and County Engineers, and the War Office.

This Committee has been nominated by the Royal Institute of British Architects to consider and report upon the use of reinforced concrete in buildings and other structures. As we all know, reinforced concrete is largely used in other countries—in America, France, Germany, Italy, Russia, Egypt, etc.—and is now coming into use here, but very slowly.

The conservative nature of our people may be responsible for part of our reluctance to use reinforced concrete, but another reason why we lag behind is that no responsible or representative body of skilled men—no one man even whose name carries great weight—has pronounced in its favor. Also Building Acts and By-laws do not facilitate its adoption. The architect and engineer hesitate to use it until the material and what can be done with it has been generally agreed upon; until, in fact, they have some assurance that it may safely be employed.

Now, as the Royal Institute of British Architects has been the promoters of this Committee, you may naturally look to its representatives for some general idea of the line of action to be taken. Exactly what may be done must be settled by the Committee itself; and in submitting to you a general rough sketch idea of a programme, it must be understood that the sketch is necessarily only an introduction, and not in any way a finished scheme, for your guidance.

First, then, it appears that we should inquire into what has been done already, and ask the owner or architects or engineers of such work for particulars, and how the buildings have stood the test of time. We shall have a Secretary who can apply to railway companies, owners of mills, private owners, architects, engineers, and others, who will no doubt willingly place the results of their experience at our service. Some of us may visit works; some have actual experience in the new system; and when we have digested this knowledge we can as a body express an opinion as to its usefulness, its safety, its permanence, and other qualities, which opinion we may fairly hope will be of value to our fellow countrymen.

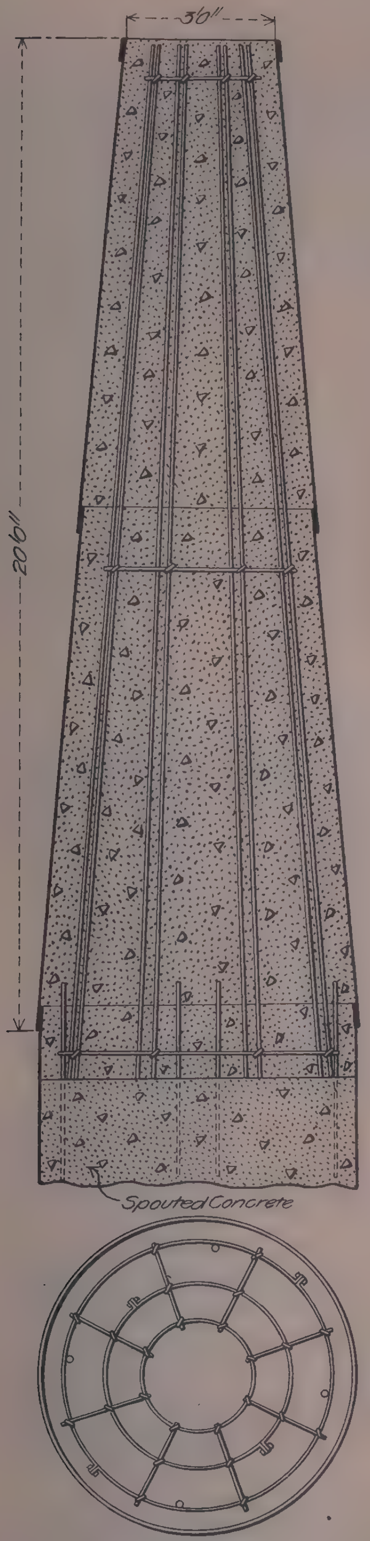
Something of this kind has been done already in other countries. The German Association of Architects and Engineers in conjunction with the Concrete Association have drawn up a report; the American Society of Civil Engineers in conjunction with various other bodies have appointed a Committee which is at present engaged on similar work, and it is suggested that we should apply for copies of such information or interim reports as may be at its disposal; the French Government also is said to have appointed a Committee to prepare a set of recommendations.

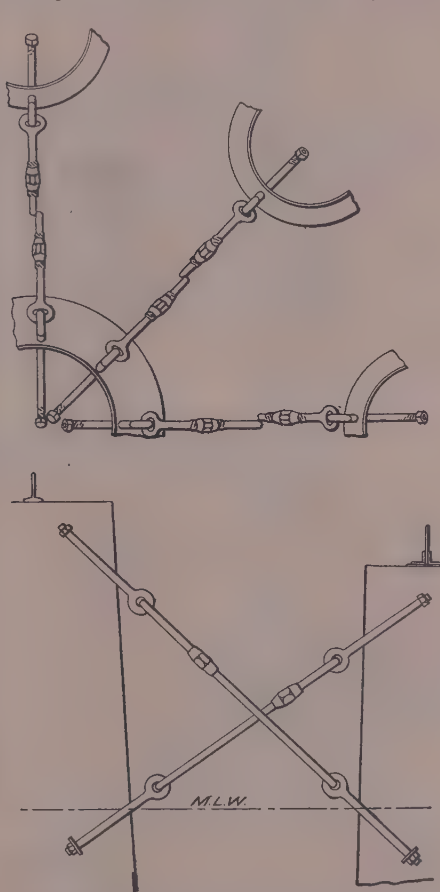
A general expression of opinion as to its value would not help other architects or engineers very much; we should therefore consider and report upon the following amongst other matters, as to which there is doubt:

(1) Whether such constructions are permanent or likely to deteriorate with time. The steel skeleton is said by all those who have studied the subject not to rust, and even when steel is embedded in a material such as coke-breeze concrete containing a proportion of sulphur there is said to be no rusting. As any reduction in the section of the metal by rust might endanger the work, we should consider if it ever does rust, and under what circumstances, so as to advise upon any necessary precautions, or to reassure the doubters on this head.

(2) The resistance to fire. We shall have to consider what has been done in experimental tests such as those of the City of Hamburg Authorities in 1895, and of the British Fire Prevention Committee just made. Also the results of tests in actual fires in buildings such as the Baltimore fire, where the conditions were exactly those we have to provide against. We may thus be able to form definite conclusions of value to all interested.

(3) The method of contracting. There are about fifty different so-called patent systems, and it is usual to entrust the design of any proposed work to one of the firms who make a specialty of this class of construction, obtaining from that firm a guarantee of strength. This arrangement is probably quite desirable; but as a certain responsibility must always lie on the engineer or architect who accepts or recommends for acceptance any such design, it is desirable for us





Reinforced Concrete Pier Top and Corner Diagonal Rods, Manila Wharf.

to define as best we may the responsibility of the parties.

For instance, it may be made clear that the contracting firm undertakes all responsibility; you may consider it wise to require that the drawings should first be submitted to the architect or engineer, and should be signed by the contracting firm or by some responsible person on their behalf. Some firms try to make a secret of their system, and object to showing the drawings.

It may appear to you that to accept a plan for floor or roof or wall or column or bridge or water tank (all matters of construction in which we are supposed to be skilled) without making ourselves acquainted with what is to be done is dangerously foolish; and if so, your opinion may have sufficient weight to settle that question. Captious interference we should all deprecate, of course, but the engineer or architect must be in command, and must know, not only what is proposed to be done, but how it should be done. We can still leave ample freedom to the experts in the design of the work, in the choice of material and method of carrying out the work.

(4) The materials also will no doubt be considered. These are: (*a*) the metal, iron or steel; (*b*) the cement; (*c*) the sand; (*d*) the aggregate, ballast or stone, etc. For the steel and the cement we shall have the standard specification of the British Engineering Standards Committee, and must inquire if qualities of the standard kinds are suitable for reinforced concrete work.

As to the sand, you know how universally the qualities of good sand are given as clean and sharp. We have to review all that in the light of recent knowledge. In America many experiments have been made which show that cleanness is not so all-essential as has been supposed, and that washing does not improve every sand. These results were arrived at by experiments on material not only seven days or twenty-one days old, but were made on pieces of various age up to three years. Certain work in that way is being done here, and when we have collected and considered the facts our opinion based on knowledge should be of value.

Next as to the sharpness. You may find that sharpness is not so important as variety in size of the grains of sand. Compactness and freedom from voids appear to play a most important part in the strength of mortar, and that freedom from voids may best be obtained by variety of size. These questions we should study with an open mind, free from ancient prejudice.

Then there is the aggregate of stone, gravel, coke breeze, etc., what proportion to use, what material to use to get the best results in given cases. If we find that washing the sand may be saved, and that concretes of leaner mixture may be used than hitherto with equal safety, we shall have done some good.

Questions arise as to the mixing. We want to know what is the proper way to mix our concrete; how much water to use; whether the sand, gravel and cement should all be mixed together and the water added, or whether the sand, cement, and water should be made first into mortar and the gravel or stone added, as recommended by some. We want to know the value of mixing machines, and whether it is wise to allow a smaller proportion of cement, say 10 per cent. less, if the concrete is mixed by machinery, owing to the fact that it is better mixed. Into all these we must inquire, so as to be able to advise our brother architects and engineers.

(5) Another subject is the carrying out of the work. Should we require that only skilled men under skilled supervision be employed; that the work be kept wetted, be stopped in frosty weather; how long the centres should be kept up, etc. All these can only be indicated as matters for your consideration and judgment, and upon which an authoritative pronouncement would be desirable.

(6) One important question which we must consider is what are the safe stresses to allow in various cases. There is apparently no such general agreement upon the safe stresses and methods of calculation as we find in regard to steel or iron, and it is possible that in the present state of knowledge we cannot tell with sufficient accuracy what are the internal conditions in a non-homogeneous beam, to enable us to determine rules which are not open to criticism or improvement with the advance of experience.

Reinforced concrete is, however, being used, and there is need of rules—tentative though they may be—to guide us until we get formulas which will command general assent. Much has been done in the way of experiment in recent years, so that we are in a much better position to test any of our theories by the results of actual work.

It may be found desirable to refer this part of our subject to a sub-committee of those amongst us who are specially qualified by reason of their mathematical attainments to pronounce upon it.

Our Commission is limited to preparing suggestions and recommendations, and therefore, any report that may be made will be in the way of advice and not as fixed and immutable rules.

How far our Building Acts and By-laws should be altered to permit of the use of reinforced concrete walls may also be considered, because as they stand they interfere with the reasonable use of the material.

There is a general feeling that our regulations as to walls should be relaxed in all buildings, at least in rural districts. The agitation for reform in this respect has not yet spread to urban districts, save in regard to the material we are studying; and it certainly seems that if the strength is increased by the use of a metal skeleton the thickness of a concrete wall may be correspondingly reduced.

We fortunately have with us municipal and county engineers and district surveyors whose experience in the working of these by-laws will be of value in restraining too much reforming zeal should we display it.

All the questions thus briefly reviewed are matters upon which the general body of architects and engineers and others interested would no doubt value the consensus of opinion of skilled and disinterested men who have studied the subject. Such an opinion will help the introduction of the material by giving those who hesitate to employ it through want of knowledge, and fear of the responsibility, the assurance of the conditions under which it may safely be used, and give that confidence which is at present lacking. It will call attention to its advantages where it has any, such as road bridges over railways, which at present deteriorate rapidly with rust.

Short Span Bridges on the Baltimore & Ohio Railroad.

Solid floor bridges for short spans on the Baltimore & Ohio Railroad have been designed of several types in which the loads are chiefly carried by steel beams and girders and the latter are entirely enclosed in concrete integral with the floor slab which at the same time affords protection against rust; provides a continuous platform for the ballast so that the track can be laid like that on the adjacent fills and may be shifted to different positions within the limits of the platform; and promotes the economy of maintenance.

The shortest openings, namely those for culverts, are covered with simple flat slabs of reinforced concrete 12-in. thick which have bearings across the full width of the side walls, 3 ft. thick. They have clear spans varying by 1 ft. increments from 5 ft. to 12 ft., and are proportioned for a live load consisting of a Cooper's E 50, 177½-ton engine and tender with an allowance of 50 per cent. for impact. The dead load, exclusive of the concrete which is assumed to be self sustaining, is assumed to be 2,000 lb. per lin. ft. of track. The consideration of it is, however, immaterial since the maximum stresses are determined from the axle loads.

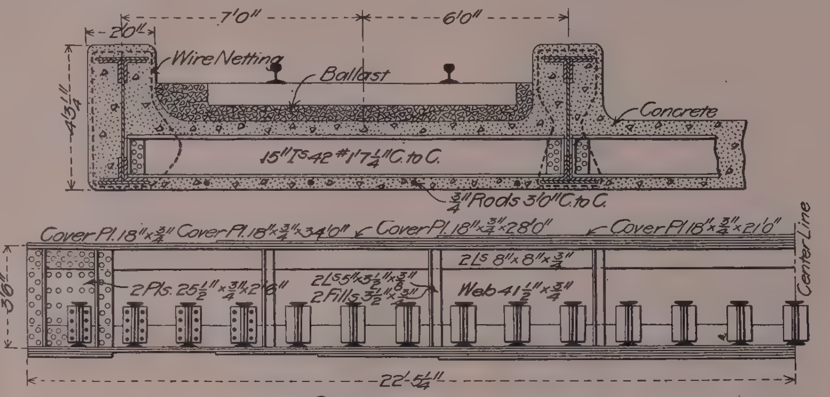
The concrete is made 1:3:5 with Portland cement and 1½-in. broken stone well rammed. It has a uniform thickness of 12-in. except at the edges, where the distance is increased 6 in. to make a fascia girder or parapet 12 in. wide to retain the ballast. Under each rail there are imbedded in the concrete a number of steel rails set close together and alternating with reversed rails closely packed between them. Between these groups and on either side of them are single rails spaced uniformly for a distance of 5 ft. each side of the track center. On the edges of the bridge, and between tracks of a double-track bridge, the spaces beyond these limits are occupied by additional rails uniformly spaced a little farther apart. The rails have at each end direct bearings 18-in. long on the tops of the side walls. The spaces between the webs of rails set close together are filled with 1:3 Portland cement mortar. It is not required that the rails shall be new, but they must be of good quality and free from cracks or serious defects, and of the full weight required in the table.

A convenient table gives the different numbers of 60, 70 and 80-lb. rails required for single and double-track bridges. A single-track 5-ft. span requires 24 60-lb. rails and the estimated cost is $106.00 exclusive of the side walls and allowing $39.00 for the concrete and $9.00 for the roadbed. If made with 80-lb. rails the same number are used and the cost is increased to $125.00. Double-track bridges of the same span require 45 rails. For 12-ft. spans 80-lb. rails only are specified and 46 of them are required, corresponding to a total cost of $352.00, allowing $14.00 for road bed and $62.00 for concrete. Single-track bridges with clear spans of 6, 7, 8, 9 and 10 ft. each require 20 60-lb. rails and from 16 to 20, 70 or 80-lb. rails. The estimates of cost are based on a price of 1½c. per lb. for the rails, ½c. per lb. for cutting and placing; $4.00 per cu. yard for materials and $2.50 per cu. yd. for labor in concreting, 60c. for materials and 20c. for materials per lin. ft. of track for road bed.

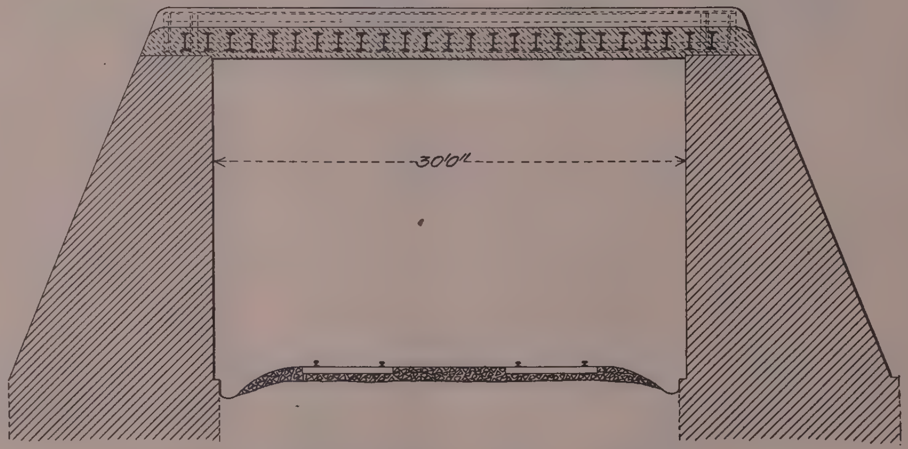
For spans varying from 12 to 26 ft. in the clear a standard construction has been designed for the loading already specified, which consists of a set of longitudinal I-beams, uniformly spaced across the full width of the bridge, which have at each end over 2 ft. of direct bearing on the side walls, and are entirely enclosed in a solid mass of concrete projecting 2 in. below the lower flanges and from 4 to 5 in. above the top flanges. In this case the concrete serves chiefly to protect the beams and secure a continuity of surface, the loads being directly carried by the girders, which are proportioned for unit stresses of 16,000 lb.

The I-beams, thoroughly cleaned and free from rust, paint, grease and dirt are strongly clamped in the required position and 1:2:4 concrete made with 1-in. broken stone is thoroughly rammed between them. The bottom, sides and upper surfaces are finished with a ½-in. coating of 1:3 mortar, rammed in with the concrete and not plastered on. After the forms are removed the surface of the concrete is washed with cement grout to fill the pores and give uniformity of color.

When the bridge is constructed under traffic the track is supported above it in such a way as to relieve the I-beams and concrete of all loads and impact until the concrete is satisfactorily set. When the platform is built on false-work parallel to the track and afterwards moved transversely to the bridge seats the latter are immediately grouted so as to secure even bearing throughout. The upper surface of the concrete is crowned so as to provide for drainage to gutters adjacent to the fascia girder and; in double-track bridges, to center gutters, all of which are provided at frequent intervals with 4-in. vertical drain pipes.



CENTER GIRDER



Undergrade Crossing, Western Maryland Tidewater R. R.

A 12-ft., single-track span requires thirteen 12-in. I-beams weighing 7,012 lb., 16.6 cu. yd. of concrete, and costs $312.00, allowing $159.00 for the beams erected, $108.00 for the concrete and $13.00 for the road bed. This corresponds to a total cost of $202.00 for material and $110.00 for labor. A 26-ft. span requires eleven 24-in. 80-lb. I-beams weighing 26,980 lb., and 49 cu. yds. of concrete, and costs $936.00, of which $563.00 is for steel, $319.00 for concrete and $24.00 for road bed. This corresponds to $661.00 for material and $275.00 for labor. Double-track bridges require two less than double the number of beams required for single-track bridges, and are estimated to cost 19-10 times as much as single-track bridges of the same span. Where old I-beams are retained in position in the new bridges they are credited at the rate of $1.00 per linear foot each. Where they are removed they are credited at 50c. per linear foot.

Short spans of more than 26 ft. are usually made with plate girders having special steel and concrete floor platforms. The character of the deck spans is clearly shown by the design for bridge 34 A, of the Washington branch, which is 78 ft. long over all and 72 ft. 8 in. long between abutments. It is proportioned for the loading already mentioned, which gives a maximum shear of 320,200 lb. and at 10,000 lb. per sq. in. requires 32 in. of net cross section in the web, which is made with a 95½x½-in. plate. The maximum moment is 5,506,500 ft.-lb. which, divided by 8ft., gives a flange stress of 688,300 lb. and requires a net area of 43 sq. in. at 16,000 lb. per sq. in. The flange is made up with two 8x8x⅝-in. angles and a maximum of three 18x½-in. cover plates, which, together with ⅛ of the web plate, gives a total net section of 46.7 sq. in. The top flange cover plates are all of them full length plates, so as to provide a continuous bearing at uniform level for the floor troughs. The girders are seated on standard cast iron pedestals and are connected together at web stiffener angles with ordinary vertical transverse sway bracing.

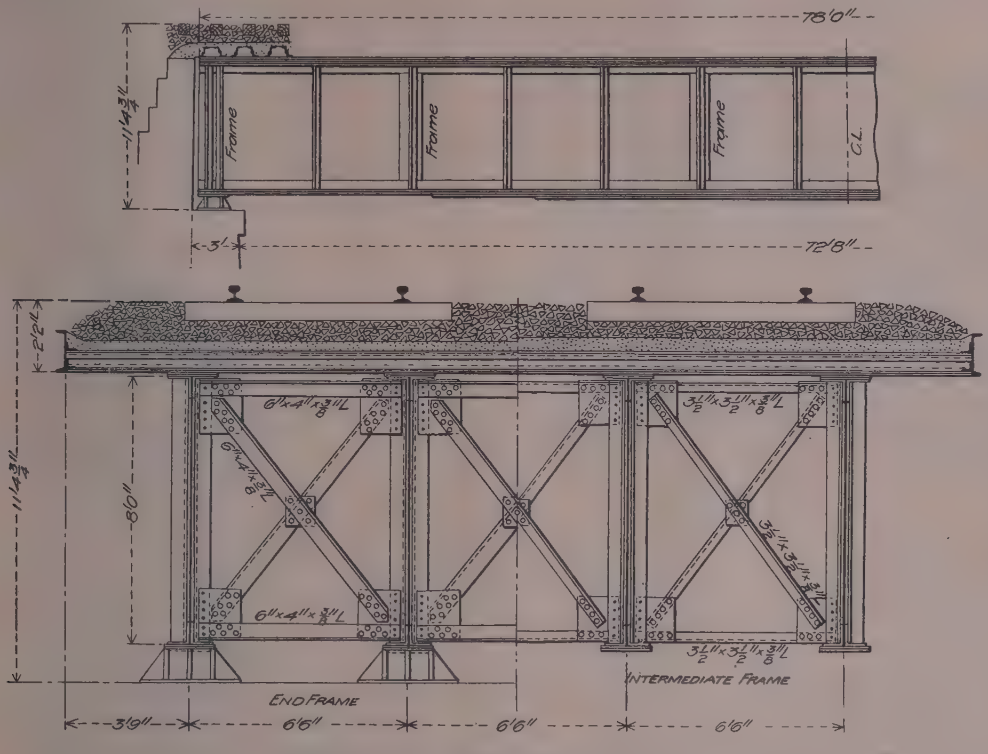
The floor consists of rectangular transverse troughs filled with concrete, above which there are 15 in. of broken stone ballast. The floor troughs are made in single lengths projecting 3¾ ft. beyond the outside girders and having their ends closed by 15-in. channels forming fascia girders to retain the concrete. The troughs are 8 in. deep and are made with 12x⅜-in. top and bottom plates connected with 5x3½x⅜-in. angles having their vertical flanges riveted together so as to dispense with side plates. The trough section has a movement of inertia $I = 60$, 59 being required by the formula

$$I = \frac{24{,}100 \times 6.5 \times 4 \times 12}{8 \times 16{,}000}.$$

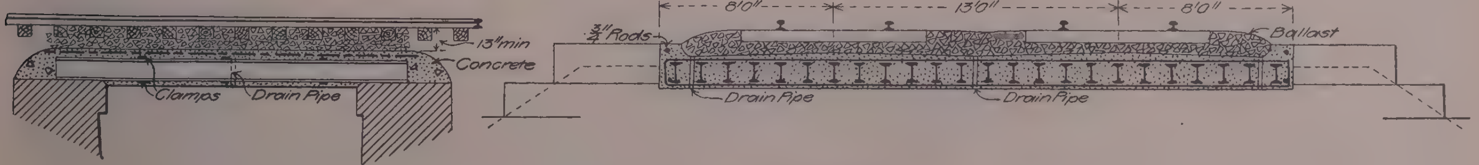
The 44-ft. 9-in. span of the undergrade crossing of the Western Maryland Tide Water Railroad on the Montclair branch of the Baltimore division is typical of the solid floor type of skew through double-track plate girder spans. Here the massive concrete abutments are skewed 53½ degrees with the track and serve as retaining walls for the deep fill. They carry three plate girders which, together with the floor beams, are entirely enclosed in a monolithic mass of concrete. The girders are wrapped with galvanized wire netting of 12-in. mesh, and the 15-in. floor beams, 19¼ in. apart, are bedded in concrete 25 in. thick, which forms a thick slab extending beyond the top and bottom flanges. Under the lower flanges it is reinforced with ¾-in. longitudinal rods 3 ft. apart. The upper surface of the floor slab is connected with the casing of the main girders, and receives stone ballast for the track. The concrete is made 1:3:5 with 1½-in. broken stone between the beams and ¾-in. broken stone on the top, bottom and sides.

All of these bridges were designed by the Engineering Department, Mr. J. E. Greiner, engineer of bridges and buildings.

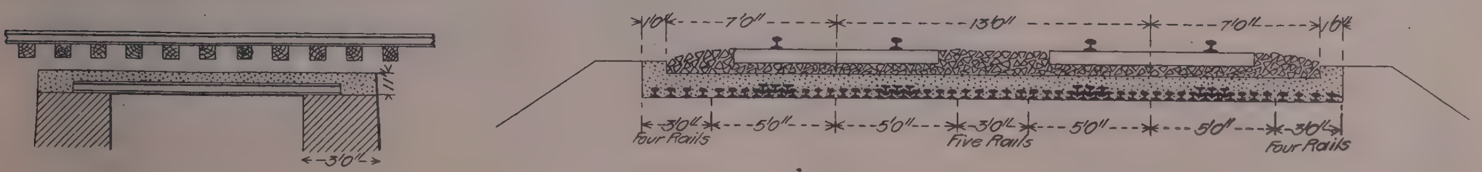
The steel work for the 44-ft. 9-in. span was furnished by the Baltimore Bridge Co., and was erected by the Railroad Co's. forces.



Bridge 34 A, Washington Branch.



Standard Concrete Steel Span.



Standard Rail Top Culvert.

A Bursting Water Tank on the roof of a large New York department store furnished an impressive lesson on May 29 of the importance of building and maintaining these structures properly. Ten people were injured, the store being filled with shoppers at the time.

The Formation of Rings in Cement Kilns.

By Carleton Ellis.

The name of "rings" has been given to the annular aggregations which frequently encrust the internal walls of a rotary cement kiln and prevent the free passage of flames and gases. There are two varieties, "mud rings" and "clinker rings." The former occur only in the practice of the wet process and in the upper or stack end of the kiln.

Mud rings form when the flame does not carry sufficient oxygen to burn away the organic matter of the slurry. With a neutral or a reducing flame the slurry sometimes bakes on to the walls of the kiln as a compact mass, increasing in size with each revolution of the kiln until draft is impaired and clinker burning becomes difficult. When such a mud ring forms the only recourse is to introduce bars from the upper end of the kiln and dislodge the mass. As the material is comparatively soft at this stage, the removal of the rings is not difficult. To prevent the formation of mud rings, sufficient air should be admitted with the fuel to give an oxidizing flame. This condition calls for 15 to 25 per cent. excess of air above that actually needed for combustion, the precise amount depending upon the organic matter in the slurry and on the local conditions.

Clinker rings are formed at or near the clinkering zone by the adhesion of the vitrifying nodules of material to the walls of the kiln. While mud rings are not generally troublesome, clinker rings are of a more serious character. They occur in the practice of both the wet and dry processes of Portland cement manufacture, and scarcely a plant is exempt from kiln troubles due to them. The shut-downs entailed often cause a by no means small loss of output.

Many kiln operators believe better results are secured when a small ring is present in the kiln than when the walls show no adhering masses, but are clean and bare throughout the clinkering zone and adjacent portions. This, if true, possibly may be brought about by an improved heat reverberative effect of the coated walls as compared with that of bare walls. If the ring only could be maintained at a very slight thickness all would be well, but unfortunately such conditions are not generally permanent, and frequently from no apparent cause the ring increases in size, the draft is impeded, combustion becomes incomplete and volumes of dense black smoke pour from the kiln stack, outwardly indicating the internal derangement of normal conditions.

The agencies causing clinker rings are in a measure obscure. Rings are especially liable to form when the mix or composition possesses a relatively low fusion point or is "easy burning." If low in lime and high in silica rings are prone to form. Pockets of sand in the clay employed may give rise to derangement of the composition. Iron oxide is an especially powerful fluxing agent and excessive amounts cause rings. If the combined iron oxide and alumina from any cause exceed one-half the total silica, ring obstructions may be expected. The presence of a small amount of moisture in the material as it approaches the clinkering zone is believed by some cement makers to be responsible for clinker rings. Possibly this may be true to some slight extent in the case of the wet process, but it is doubtful if, with the dry process, moisture is in any way instrumental in forming clinker rings.

The obstruction occurs usually at a point in the kiln about 3 or 4 ft. beyond the zone of highest temperature. In this region the advancing material, if of the imperfect composition mentioned, is fused, superficially at least, and frits on to the walls of the kiln as an annulus or ring. The theory has been advanced that the period of such incipient fusion is followed by a chilling action due to the liberation of carbon dioxide from the interior of the clinker nodule. Calcination, that is the removal of carbon dioxide from the limestone, is ordinarily by no means complete at the time of entry of the composition into the clinkering zone and of course the removal of the residual carbon dioxide involves a heat absorbing or endothermic reaction at a point where only exothermic reactions should prevail. It is thus possible to conceive of a set of conditions causing the clinker forming mass to "freeze" to the walls. Under such an assumption, improved calcination should decrease the troubles from clinker rings. This has been borne out to some extent in practice, more particularly with the process employing stack gas to aid in developing an energetic calcining flame.

Not always, however, can we explain the formation of rings primarily from a chemical standpoint. The writer has noted that two adjacent kilns alike in construction and lining and put into commission at the same time, although supplied with identically the same raw composition, showed different behavior as regards "ringing" tendencies. One kiln gave practically no trouble from rings and was operated continuously, while the other kiln was frequently choked by these obstructions and was out of commission nearly a third of the time. In the prevention of clinker rings much depends on the kiln operator. By shifting the direction of the flame during its formative stage the growth of the ring sometimes may be prevented. The two kilns mentioned were in the hands of one operator, and while he was able to keep one kiln "clean," he was helpless as regards the other. This is another instance of the oft-noted idiosyncrasies of machines, which, apparently alike in construction, behave differently and possess their own "personal equations."

The removal of clinker rings is a time-consuming operation. Commonly the mass is punched with long heavy bars until dislodged. Water removal is less laborious. In carrying out the latter treatment a 1¼ to 1½-in. wrought-iron pipe 30 to 40 ft. in length is tipped at one end with a short steel nozzle and is connected at the other end by a flexible hose to a water tap. Water is turned on and workmen prod the base of the ring with the pipe. The expansive, almost explosive, force of the steam generated in the mass soon fractures and dislodges the obstruction. The workmen should protect their faces during this operation, especially if the patching holes or other openings in the hood are of large dimensions.

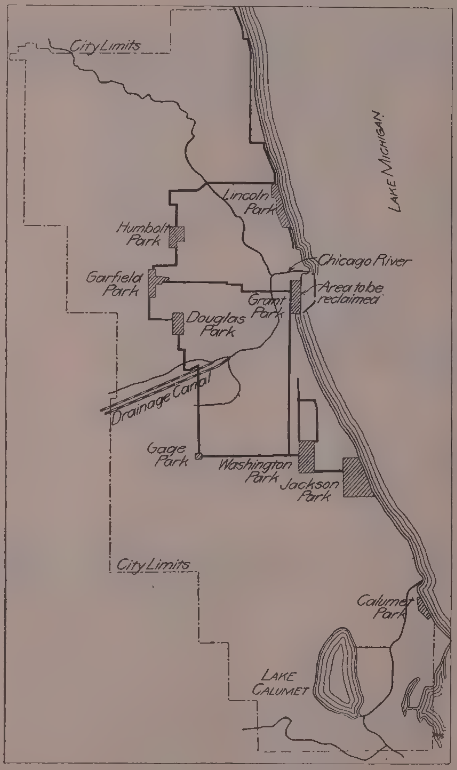
However conscientious the cement chemist may be and however skilful the kiln operator, rings often form persistently under the usual conditions of firing, especially with the axial flame method of burning powdered coal. It is of interest to note that the impinging flame burning in a stack-gas-diluted atmosphere gives much less trouble from rings than ordinary firing, and in plants where this system is installed rings practically have become difficulties of the past. Should it eventually be fully established that the use of the stack-gas-tempered impinging flame overcomes ring troubles completely, its application in many plants will lead to greatly increased outputs of cement. Improved calcination resulting from the tempered flame is offered as a partial explanation of the smoother operation of the kiln under the stack-gas system.

The Electrification of the Rochester Division of the Erie R. R., between Mt. Morris and Rochester, N. Y., was awarded last week to Westinghouse, Church, Kerr & Co. This section is about 35 miles in length, and work on it has already been commenced. The next section in Western New York to be equipped is from Avon to Corning, a distance of about 70 miles. The single-phase system has been adopted and the operating voltage will probably be 11,000 volts. Only one sub-station, located about the middle of the line, will be required. Power will probably be taken from the transmission lines of the Ontario Power Co., which cross the tracks to be electrified. The Electrical Commission of the Erie R. R. has now practically completed its work of preparing estimates upon the cost of electrification of the Greenwood Lake and other suburban divisions of the Erie Railroad near New York.

Reclaiming the Site of Grant Park, Chicago.

An area 1,300 ft. wide by 6,500 ft. long and embracing 205 acres, is being reclaimed along the shore of Lake Michigan in front of the central business district of Chicago to form the principal part of a new city park. This park will extend from Park Row north along the shore of the lake to Randolph St., and toward the lake from Michigan Ave. It will embrace a total area of over 250 acres, all of which is within a few minutes' walk of the retail and office building district. It will also serve a large area of the congested tenement districts of the city that are at present practically shut off from park privileges. The new portion of the park site is being reclaimed and will be developed by the South Park Board, of Chicago. This board is a State organization, entirely distinct from the municipal government of Chicago, and together with the West and the North Park Boards controls the building and maintenance of all of the public parks within the corporate limits of Chicago.

The site of the park was all, or practically all, covered with water before the city was built along the shore of the lake, the original shore line being roughly along the lake side of what is now Michigan Ave. After the Chicago fire in 1871 a strip of land 500 ft. wide was reclaimed along Michigan Ave., with debris from the buildings that were destroyed in that fire. Prior to the reclamation of this 500-ft. strip of land the tracks of the Illinois Central R. R. were built on pile trestles across the partially submerged land, 200 to 300 ft. out from the original shore line of the lake and roughly parallel to Michigan Ave. The tracks of this railroad are now on a 200-ft. right-of-way, the inner line of which is 300 ft. from Michigan Ave. The 300-ft. strip of ground between Michigan Ave. and this railroad right-of-way has for many years been developed as a portion of the South Park system. A large monumental stone building, which contains an art museum, has also been erected on this narrow parkway.



Map Showing Park System.

The area that is now being reclaimed is outside of this railroad right-of-way and will require about 7,000,000 cu. yd. of filling, in place, to bring it to the required grade. An old inner breakwater, consisting of a rock-filled timber crib, was built along the lake side of that right-of-way, with an outer breakwater of the same type, 1,300 ft. off shore, on the line of what is now the shore line of the new park. Some time after the 500-ft. strip of land was reclaimed and the old inner breakwater had been covered with the fill, a second outer breakwater was built 1,600 ft. farther off shore than the first outer breakwater. The area between the old inner breakwater along the railroad right-of-way and the first outer breakwater was covered with water from 2 to 20 ft. deep. This area is now being reclaimed to form a part of the new park and will be brought up 15 to 30 ft. above the lake level. The newly reclaimed area and the 300-ft. strip will both be included in the new park, which will have a total area of over 250 acres.

The 200-ft. railroad right-of-way has been depressed about 17 ft. below the general level of the park on both sides of it. A stone masonry retaining wall and an underground suburban passenger station were built on the land side of this right-of-way by the railroad company during 1895 and 1896. A concrete retaining wall, 21 ft. high and 6,250 ft. long, is just being completed for the railroad company on the opposite side of the right-of-way by the Great Lakes Dredge & Dock Co., of Chicago. This latter wall and the methods followed in its construction were quite fully described in The Engineering Record for Jan. 27, 1906. The central passenger station of the Illinois Central R. R. is at Park Row, so that suburban traffic is the only passenger business that will be carried through the park. This traffic is so fully adapted to electric traction that it is believed that the tracks on which it is carried will be electrified before many years. A large distribution freight yard is located beyond the upper end of the park, however, and will doubtless be continued as such for some time.

The central feature of the park will be an immense museum building, which will be erected with a fund of $8,000,000 that was given for this purpose by the late Mr. Marshall Field. This building will contain a museum collection that was brought together at the close of the Columbian Exposition, which collection is now located in the old art palace building of that exposition in Jackson Park on the south side of the city. A 500x1,000-ft. site has been reserved for this museum building at the center of the middle third of the park. The general ground elevation in the immediate vicinity of this building will be brought up to 30 ft. above Chicago datum, which datum is 1 ft. below the mean lake level. The surface will be terraced down to 23 ft. above datum at the corners of a rectangle surrounding the building. The elevation of this rectangle will be practically maintained on the land side back to the concrete retaining wall along the railroad right-of-way.

The south and north thirds of the newly reclaimed area will both be devoted to general playgrounds. They will both be at a general elevation of about 8 ft. above datum and will be graded up to the terraced rectangle around the museum building and to higher ground on the other three sides. Four monumental bridges, 200 ft. wide, are to be built across the railroad right-of-way and will carry roadways which will connect with a system of drives in the park. The north corner of the park on the lake side will be brought up to 30 ft. above datum and the south corner on that side to 28 ft. above datum. A broad drive along the shore of the lake will connect these two high corners, which will also be connected by drives with the bridges over the railroad right-of-way. A concrete sea wall over 6,000 ft. long will be built along the lake side of the park to about 7 ft. above the mean lake level. From this wall terraced slopes will be built up to the drive connecting the two high corners of the park on the lake side. This drive is on a gradual descent from both high corners to the transverse center line of the park, where it will be 13 ft. above the lake. The breakwater along the outer line of the basin in front of the park is expected to prevent any wave action sufficient to overtop the concrete wall and damage the park slopes. The basin in front of the park is used principally by pleasure craft since merchant sailing vessels have practically disappeared from the lake. A yacht harbor is being built at the south end of the park in connection with this basin, and space will be provided along the harbor and within the park for yacht club buildings.

The State Legislature of Illinois passed a law in 1896 which permitted the reclamation work to be started soon afterward on the north part of the area that is now reclaimed. A second law passed in 1903 gave the authority to begin work on the remainder of the area. The first reclamation work was done in 1897, but up to 1904 the work had been carried on slowly, owing to a lack of funds. In all about 2,500,000 cu. yd., net, of filling had been placed in the area at the beginning of 1904. Prior to 1903 this filling had all been done with various kinds of refuse from buildings, street sweepings and material from excavations for new buildings which was hauled out in wagons. Entrance to the area during this time was obtainable over only four viaducts built across the railroad right-of-way. The contents of all the wagons crossing these viaducts were very carefully examined and all garbage and perishable material excluded.

Suction Dredge used in Reclamation of Grant Park Site.

Derrick Handling Bottom-Dump Car Body.

In 1903 a contract was awarded to the Great Lakes Dredge & Dock Co., of Chicago, to furnish 130,000 cu. yd. of material a month to be used in reclaiming the submerged site of the park. This company has had a large floating equipment in operation every season since this contract was awarded, and has placed considerably over 1,000,000 cu. yd. of material, net, back of the breakwater since the beginning of 1903. Most of the material has been obtained from dredging operations in the Chicago River and its branches. These dredging operations have practically all been carried on by the Great Lakes Dredge & Dock Co., or by the contracting companies of which this company was formed. The material is dredged from the river with dipper dredges and loaded on scows. These scows are then towed with tugs to the basin back of the breakwater along the outer line of the area that is being reclaimed, and their contents dumped into the basin.

This method was followed without any variation until a large portion of the site of the park had been brought nearly to the level of the lake, with a fairly deep channel along the lake side at one corner of the park site and back of the breakwater. A large suction dredge was then put in operation, re-handling hydraulically the material dumped into this channel from the scows. The portion of the area already at about the lake level is brought 5 to 15 ft. above that level with this suction dredge. As the fill was completed over the inner part of the area this dredge was moved out toward the breakwater until now an area of less than 20 acres remains to be brought to the level of the top of the breakwater, which is about 5 ft. above the normal lake level. The suction dredge that is at present at work is built on a 33x100x10-ft. scow and is equipped with a Morris centrifugal pump having 20-in. suction and discharge pipes. This pump is driven by a 17 and 34x20-in. compound engine, which is supplied with steam by two 8x10-ft. locomotive boilers. The discharge pipe leading from the dredge is laid on pontoons across the open water to the fill already made. A 3-yard dipper dredge is used in connection with this suction dredge. This dipper dredge throws up a berm along the water side of the fill that has been brought to about the lake level in order to confine the water discharged from the suction dredge until the material carried by this water is deposited.

The Great Lakes Dredge & Dock Co. is also dredging the basin between the shore line of the park and the outer breakwater to a uniform depth of 21 ft., under a contract with the United States government. This work will require in the neighborhood of 500,000 cu. yd. of excavation in 12 to 18 ft. of water and is being done with a 5-yd. dipper dredge. The material is loaded on scows and hauled to the channel that has been left open in the vicinity of the suction dredge. This 5-yd. dipper dredge is built on a 33x88x10-ft. scow. It has a 42.5-ft. boom and a 40-ft. dipper arm. The dipper is manipulated by two double 15x18-in. hoisting engines, and the dredge is equipped with two double 8x12-in. swinging engines.

Since early in 1905 the Illinois Tunnel Co., of which Mr. George W. Jackson is general manager and chief engineer, has hauled out through the tunnels of the Chicago Subway and dumped on the site of the park the material excavated from the sites of practically all of the large new buildings in the several square miles of the business district of Chicago that are served by the Subway tunnels. An incline was built across the 300-ft. strip of park between the Illinois Central R. R. and Michigan Ave., from the tunnel system of the Chicago Subway to a viaduct over the railroad right-of-way. The tracks in this incline are extended across the viaduct and connect with a system of tracks on the fill that has been made. The tunnel company was granted the privilege to build this incline, with the provision that the incline would be removed when the filling for the park had been completed, or at the request of the park board. The company furnishes the material free of charge to the park board and has already hauled out over 700,000 cu. yd., allowing for shrinkage and settlement of the soft fill on which the material is dumped. It has also hauled upwards of 300,000 cu. yd. of material to the park site in wagons from shafts in other parts of the city.

The material that has been hauled out to the park site by the tunnel company practically all consists of the stiff blue clay that is removed in making excavations for buildings in the central business district of Chicago. The novel methods that have been used in making these excavations since the service afforded by the Subway has been available were fully described in The Engineering Record for March 10, 1906. In brief, a chute lined with cast-iron is built down to a by-pass from the tunnel. The materials to be taken out are hauled to the mouth of the chute in the excavation and dumped down the chute directly into tunnel cars in the by-pass. Trains of 6 cars are hauled out to the incline by an electric locomotive. These cars are hauled up the incline, one at a time, by another electric locomotive, and then from the mouth of the incline to the point where they are dumped by a small steam locomotive. As much as 40,000 cu. yd. of material have been removed in this manner from the excavation for the basements for a single building before the old building on the site was wrecked and without any indication whatever on the surface that the excavation was being made. The average rate of removing the material from a building excavation is about 1,000 cu. yd. in 24 hours, but as high as 2,100 cu. yd. have been removed from a single basement in 24 hours. Two trains of cars, a switch engine at the by-pass and an engine hauling the trains between the chute and the incline is the usual equipment required to handle the excavation from a building, as compared with the large number of teams and wagons required under ordinary conditions, and the nuisance from handling so many teams in the city streets.

The incline from the subway tunnel was built across the 300-ft. strip of park in open cut for a distance of 250 ft. This cut was 16 ft. wide and had a depth gradually increasing from 6 to 30 ft. It was made through the material with which the strip of park was reclaimed and through the soft clay under that material. Owing to the location of the incline, the excavation had to be made with the least possible damage to the ground surface. The cut was very successfully made by driving a line of steel sheet piling on each side of its site before any excavation was started. The steel sheet piling used in connection with this work is an extremely simple form, and was built according to a design devised and patented by Mr. Jackson. It consists of ordinary steel channels and I-beams. The channels are placed together in pairs, each pair forming a hollow square. The two channels are spaced apart by sleeves on bolts which hold them together, the spacing being just sufficient to permit the web of an I-beam to pass between the channels. The I-beams and pairs of channels are driven alternately, with the flanges of the I-beams inside the hollow squares formed by the pairs of channels, the combination making a strong continuous sheet pile that is easily driven and is practically water tight. The steel piling was driven to a depth of 10 ft. below the bottom of the trench with an ordinary drop-hammer pile driver. An old timber dock was cut through in the driving, the steel piles readily cutting through heavy timber piles in the dock.

The excavation was made after the piling was driven. Two narrow-gauge tracks were extended into the cut from the viaduct over the railroad right-of-way and the material hauled out on cars on these tracks and dumped in the fill of the lake front. When the cut was completed a 9x12.5-ft. double-track tunnel section built of concrete was placed between the two rows of sheet-piling, and the material back-filled over this tunnel section. A neat frame building has been erected over the entire incline and is the only indication from the surface of the presence of the latter.

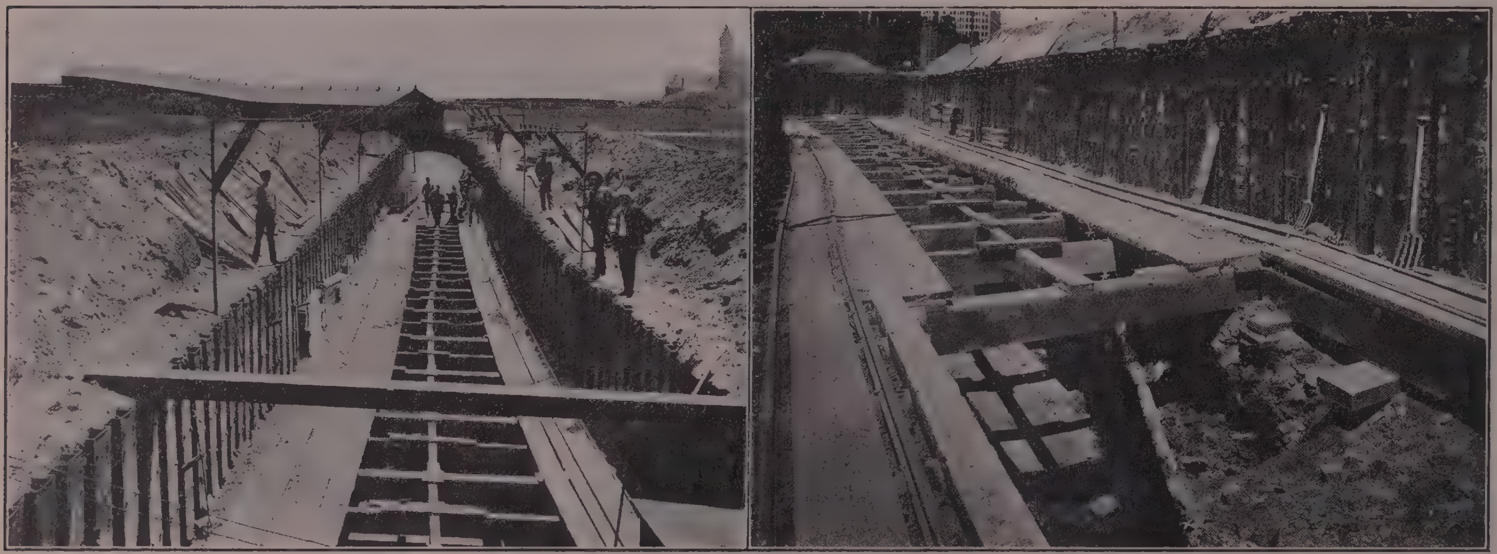
The material that is hauled out through the incline by the tunnel company has mostly all been used in bringing to grade the rectangle around the site of the museum building. This portion of the park site had already been brought to 5 to 8 ft. above the lake level by material from wagons and by the suction dredge before the tunnel company commenced operations. A temporary pile trestle, 25 ft. high, was first built just back of the wall on the lake side of the railroad right-of-way and parallel to the latter for about 500 ft. in both directions from the mouth of the incline. A fill was then made from tracks on this trestle with a special type of side-dump tunnel cars which has been designed by Mr. Jackson. When the fill had been brought up to the top of the trestle a system of parallel tracks and loops was laid out on the fill and the work was continued from these tracks.

After the fill along the wall had reached a width of about 200 ft. and a height of approximately 25 ft. above the lake level, work was commenced on one end of the rectangle and a fill of practically the same cross-section as that of the fill on the land side of the rectangle is approaching completion around the other three sides. An interesting method has been employed in dumping the cars used in hauling out the excavated material since the trestle was covered. A stiff-leg derrick, with a 60-ft. boom, is mounted on a traveling platform, which moves along on rollers on top of the fill between a track on each side of the latter, the tunnel cars being operated on these tracks. The tunnel cars used in connection with this derrick have loose wooden-box bodies, 10 ft. 8 in. long, 3 ft. 8 in. wide and 4 ft. high, with a capacity of about 5.5 cu. yd. The loose body of each rests on a steel-frame car, with a flat top and two four-wheeled trucks. The car bodies are picked up by the derrick, swung out over the edge of the bank and dumped. The bottom of the car body is entirely loose from the sides. The boom of the derrick carries a block and fall on which is suspended horizontally a rectangular frame. This frame is somewhat smaller in plan than the car body and is built up of steel channels. The car body is swung directly from this frame by chains on the latter. Two iron straps are fastened vertically on each side of the car body. These straps each have a ¾-in. hole in their upper end. Four short chains on the steel frame are each attached to one of these iron straps with a clevis and carry the sides of the body. The bottom of the body is carried on one side by two more chains on the frame, which are similarly attached, and on the other side by a trigger arm on a chain on the frame. The chains carrying the bottom are long enough to cause the latter to drop about a foot when the body is raised, loosening the contents of the car with the jerk. The car is dumped with a fall line, which springs the trigger holding one side of the bottom of the body. The material is dropped 10 to 40 ft. with the result that the shrinkage of the fill made in this manner has been very slight.

A large portion of the filling that has been done with wagons has been carried on by Mr. W. J. Newman, teaming contractor, of Chicago, who devised the carrying frame and tripping device that is used in handling the loose bodies of the tunnel cars with the derrick. This same device has also been used in handling loose, bottom-dump wagon boxes. A special form of tramway for the wagons in which the material is hauled out on the fill, has also been devised by Mr. Newman. The details of the construction of this tramway are shown in an accompanying illustration. Old railroad ties are first laid on the fill, then an old steel I-beam is laid flat on these ties to form a trackway for each wagon wheel. These I-beams are each laid on a plank, which is of such size as to permit the flanges of the I-beam to just have bearing on the ties and to carry the web of the I-beam. A plank is also spiked to the ties on each side of the I-beam to hold the latter in place. The two planks and I-beam provide a path for each horse to travel. This tramway is built entirely of second-hand materials. Wagons holding 3 to 4 cu. yd. of material from basement excavations have been hauled over the tramway by a two-horse team when the fill on which the tramway was built was so soft that the same team could scarcely pull an empty wagon across it.

About 5,000,000 of the 7,000,000 cu. yd. of filling required to bring to grade the portion of the park that is being reclaimed have been put in place. At the present rate of progress 75 per cent. of the remainder will be finished by the end of 1906 and 40 acres of the site will be surfaced. The final grading and surfacing of the site will be completed by the end of 1907. No definite decision has been made on the plans for the museum building.

The work that is being carried on in reclaiming and grading the site for the new park is under the direction of Mr. Linn White, engineer for the South Park Board. The construction of this and the other parks controlled by the South Park Board is also under the direction of Mr. White.

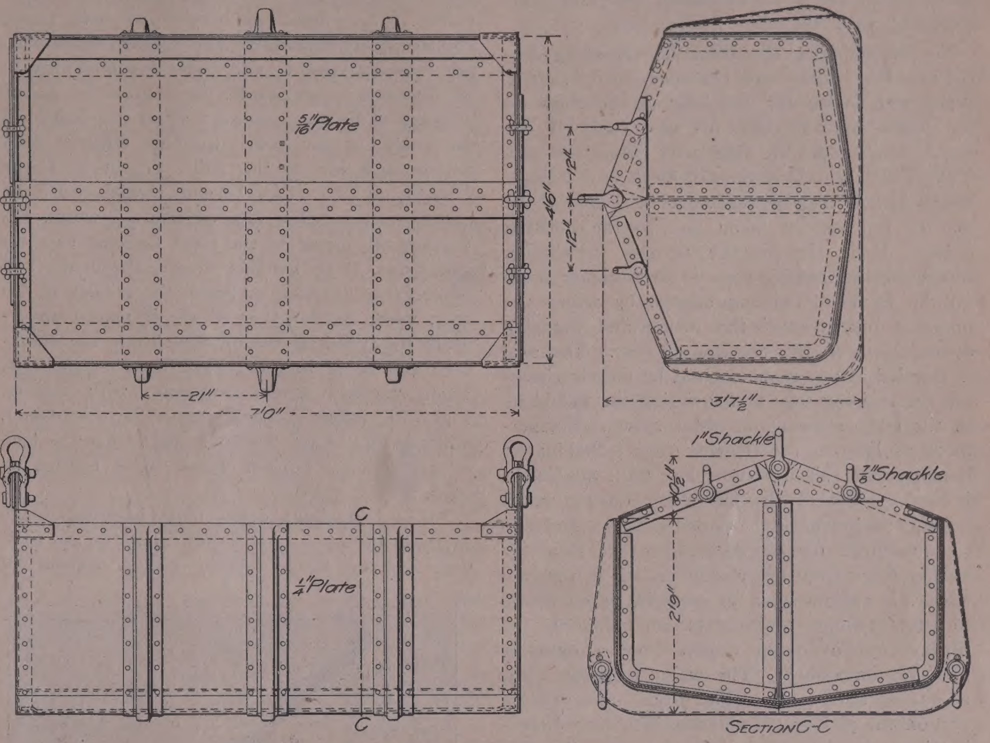


Views Showing Excavation for Incline from Subway Tunnels and Line of Old Dock Cut by Steel Piling.

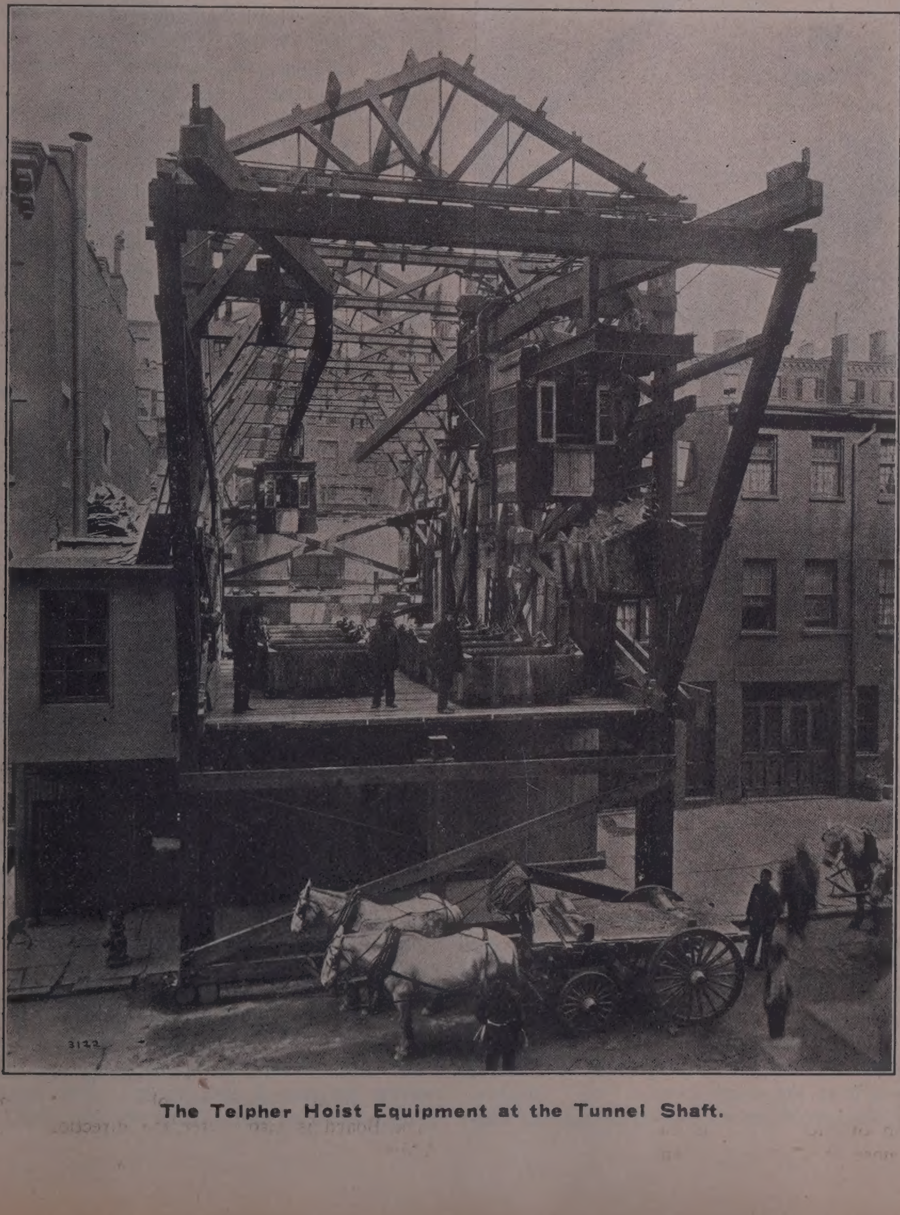
Handling Spoil from City Tunnel Workings.

An unusual method of handling material from tunnel workings has been recently placed in operation by the United Engineering & Contracting Co. in connection with such an undertaking in New York. Owing to the magnitude of the work and a desire to prosecute it with the utmost rapidity and minimum interference with street traffic and to work throughout the twenty-four hours of the day without undue disturbance or noise, it was decided to transfer the material directly from the tunnel cars to wagons in the street for removal without dumping from the skip to the wagons, or by employing cages and dump cars, the methods commonly employed on similar work. Double handling is thus avoided and the space and facilities usually necessary to accommodate the hoisting equipment and cars at the top of the shaft are reduced to a minimum. For this purpose a quick-dumping skip was designed, and a special telpher hoisting and handling system adopted. The equipment enables the skips to be loaded in the tunnel working in the usual manner, thence hoisted directly to the surface and delivered direct to wagons for removal in a single operation, without dumping or intermediate handling, the telphers being so located as to travel from over the shaft opening directly to and above the wagon in the street. The telphers are electrically operated and heavily powered for rapid hoisting, and as the skips permit of instantaneous dumping, the equipment has proved very rapid.

The important features of the new design of skip are its form and quick-dumping construction which facilitate loading in the tunnel and direct handling to wagons at the top of the shaft, and rapid unloading by derrick at the dumping point. It consists of a divided rectangular box of steel plate, opening longitudinally through the middle, the two halves being hinged at the upper rim at both ends, as indicated in the accompanying detail drawing. The box is lifted ordinarily by means of rings at the hinged points, by which the box tends to remain closed whether empty or loaded. For dumping, there are rings fastened to the lower outside edge of each half to which tripping ropes are fastened for parting the two halves and thus clearing the load. In order to facilitate the dumping operation, auxiliary lifting rings are provided on the upper rim of the two ends of both halves, by which the unloading derrick is arranged to hoist the skip. The location of these auxiliary rings is such that, while the halves will tend to remain closed, the load is very nearly balanced, the lines of support, passing between the centers of gravity of the two sections of the skip. The result is that, when supported by the auxiliary rings, the two sections may be separated with a very slight pull, estimated at less than 500 lb., upon the tripping rope, in dumping the skip loaded with 3 cu. yd. of material.



Details of New Type of Quick Dumping Skip.



The Telpher Hoist Equipment at the Tunnel Shaft.

The standard design of skip is 7 ft. in length by 4½ ft. wide by 2½ ft. deep inside and is built of ¼-in. steel plate, reinforced by stiffening angles and plates at the corners and edges and with three ribs spaced equally on the sides and bottom. The upper end rims of either half are strongly reinforced by angles, and 5/16-in. corner plates to withstand the lifting stresses through the supporting rings. Although the halves tend to remain closed whether empty or loaded, latches are provided at both ends for locking them together when the skip is being hoisted up the shaft; this precaution is taken to guard against possible accident from opening, which might result should the skip strike the sides of the shaft. The latches are, however, always unlocked before being handled by the unloading derrick for dumping. A large number of additional skips are to be built which will involve improvements over those now in operation in the use of ribs of pressed steel instead of standard steel shapes used in the original design.

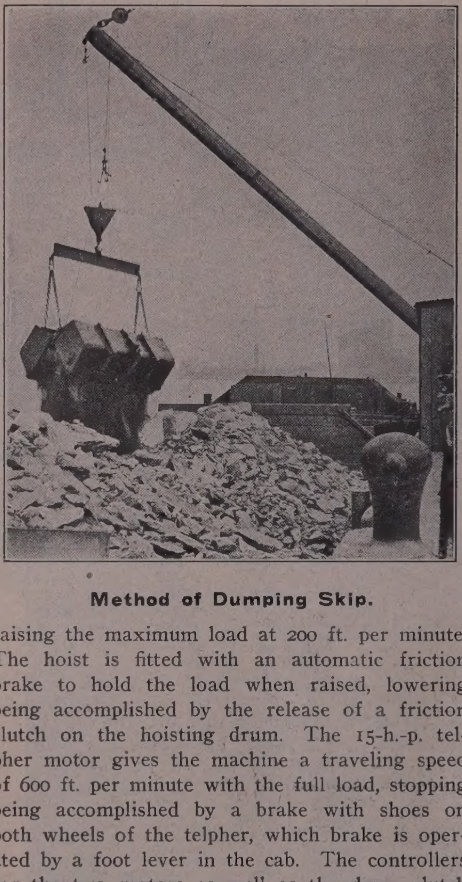
The skips are handled by the telpher hoists and derricks by means of I-beam spacers with chains at the ends for hooking to the skip. The spacer is 8 ft. long with a supporting ring at the middle and rings at the ends for the ¾-in. lifting chains, one at each end of the spacer at the telpher hoist and two at each end of the unloading derrick spacer at the dumping point, all of which are 30 in. in length, with hooks for engaging with the skip lifting rings.

For the dumping operation the unloading derricks at the docks are equipped with tripping ropes with hooks for attaching to the rings on the lower outside edges of each half of the skip. These ropes are light wire cables and join a short distance above the fall block into a single rope which is thence passed over a sheave at the end of the derrick boom and to the hoisting engine. It is the practice at this installation to operate the tripping rope by an auxiliary drum on the Lambert hoisting engine, by which the operator may control the lifting and dumping operations with the greatest of ease. The skip is emptied at any point desired by merely checking the tripping rope and lowering the fall block of the end of the boom about 2 feet. Furthermore as long as the tripping rope is held after dumping, the skip does not close until the skip is hoisted by aid of the fall block, during which hoisting the halves close together quietly The total time required for dumping, from the time the skip is lifted from the wagon until it is replaced empty, is seldom over 30 seconds, as compared to 4 to 6 minutes required for unloading the ordinary type of dump wagon from a dumping platform on a dock. The wagons approach the unloading derrick in regular order, and pass on and off the pier in 1¾ minutes, including the unloading operation, while in many cases they are released in less than one minute.

The use of the telpher electric hoists for handling skips eliminates the usual extensive storage facilities at the shaft required by the derrick method of handling and reloading wagons. There are two telphers installed, one for removing empty skips from the wagons returning from the dock, where the material is dumped, and the other telpher for immediately replacing them with loaded skips. The telphers operate on separate elevated runways, which are supported 33 ft. above the street by a heavy timber framework surmounted by roof trusses, which extend from over the shaft to the street with sufficient overhang to permit the telphers to travel out over the wagons. The structure is but 23 ft. wide, the entire shaft workings requiring, therefore, but one city lot. The runways consist of one 12x16-in. stringer for each telpher on top of which is laid a 30-lb. T-rail with stop blocks at both ends. They are hung 10 ft. between centers over the shaft opening, but spread apart at the street to facilitate simultaneous loading of two wagons. The runways are supported by 1¾-in. rods from heavy timber roof trusses spanning the framework on 11 to 13-ft. centers. In the forward part of the structure there is an operating and storage platform, 12 ft. above the sidewalk, which protects the latter and serves for the storage of extra skips.

The telpher hoists, which are of 10,000 lb. capacity, are designed for long lifts to enable them to lift directly from the tunnel level, and have motors of large capacity for hoisting the load at a speed of 200 ft. per minute. Each machine consists of a motor-driven telpher with a trailer trolley, from which are suspended the hoisting apparatus and the operator's cab. The telpher consists of a cast-steel frame with two 16-in. track wheels in tandem and is driven by a 15-h.-p. reversible crane motor, with driving gears running in an oil bath. The trailer is similar to the telpher but without motive power, and the two are connected by a 9-ft. pivoted spacing bar. From one side of the telpher frame are suspended two heavy pivoted cast-steel "downcome" frames, which come down along the side of the stringer and reach across underneath it, and these support a pivoted steel suspension-bar, which serves as a support for one end of the hoist frame; the other end of the hoist is carried by the single downcome from the trailer trolley. The connections between the hoist frame and both suspension-bar and trailer downcome, are thus arranged to allow absolute flexibility in all directions, and permit the load to be placed at quite a distance sideways from the center of the track, as the entire machine adjusts itself to the direction of the pull. The hoist frame consists of two 12-in. I-beams, which with the operator's cab below, are of unusual width, 8½ ft. over all, owing to the large hoisting capacity and speed. The hoisting motor, the drum, and the gearing are located below the telpher in the rear, while the hoisting sheave is placed underneath the trailer at the extreme front, the operator's cab being in the middle between the two. Each machine weighs complete, with motors, 20,000 lb., 15,000 lb. being carried by the telpher, and 5,000 lb. by the trailer, so that when the load of 10,000 lb. is hoisted, 15,000 lb. is carried by each.

There is a single-drum hoist designed for a total lift of 125 ft. and driven by a 75-h.-p. General Electric series railway motor, capable of raising the maximum load at 200 ft. per minute. The hoist is fitted with an automatic friction brake to hold the load when raised, lowering being accomplished by the release of a friction clutch on the hoisting drum. The 15-h.-p. telpher motor gives the machine a traveling speed of 600 ft. per minute with the full load, stopping being accomplished by a brake with shoes on both wheels of the telpher, which brake is operated by a foot lever in the cab. The controllers for the two motors as well as the drum clutch lever, are located in the cab and thus all necessity of signalling is entirely obviated. The motors are operated from the 220-volt mains of the Edison service, as is also the lighting equipment of the structure. Hoisting at night is facilitated by a cluster of lamps attached to the under side of the operator's cab, which throw their light directly downward on the skip and into the shaft.



Method of Dumping Skip.

Labor is reduced to a minimum, there being required at the shaft only one operator for each telpher and one or two men on the platform for hooking and unhooking the chains. At the dock only the hoist runner and one man to fasten the derrick chains to the skips are necessary. The skip latches are unfastened before the skip is raised from the wagon.

It has been found that about 25 per cent. more material can be handled by this system than by the usual methods and equipment. The total time of handling loaded skips from the bottom of the shaft until placed on the wagons in the street for removal, averages continuously less than 60 seconds, having under favorable conditions been accomplished in 30 seconds, thus showing the large saving of time and labor effected by the single handling.

A further advantage of telpherage is that the operation is entirely noiseless, a feature of considerable importance as the shafts are located in a residential section of the city and work is carried on day and night.

This method of handling tunnel spoil and the skip was designed by Mr. George Perrine, 22 William St., New York, and Mr. D. L. Hough, New York City. The Dodge Coal Storage Co., of Nicetown-Philadelphia, designed and furnished the telpher machines. Mr. Marshall W. Brown is engineer for the contractors now operating this plant.

Comparison of Heating and Ventilating Plants Installed in Chicago Public School Buildings at Various Periods.

The following analysis of the cost of installation, fuel consumption, maintenance and efficiency, is presented through the courtesy of Mr. T. J. Waters, chief engineer of the Board of Education of Chicago, under whose administration the modern systems were installed, and by whom this information was compiled.

For the purpose of comparing the cost of installing heating and ventilating plants in Chicago public school buildings at two different periods, Mr. Waters selected two three-story school buildings, one constructed when buildings were equipped with direct and indirect radiators with mechanical ventilation, and the second marked by the omission of all direct radiation and the location of the entire apparatus in the basement. The two buildings contain 17 classrooms above the basement, each. The first structure was built in 1889 and the heating and ventilating equipment cost $13,715; the second was built in 1894 and its heating and ventilating equipment cost $6,080.

In the former building there was installed the direct and indirect system of heating, with mechanical ventilation. The direct system consists of pipes or wall coils secured to wainscoting and extending around two sides of a classroom under windows. The indirect system consists of radiators suspended from floor joists in the basement directly under vertical ducts leading to classrooms. Usually there is an individual radiator and duct for each room. The cold air is introduced through galvanized iron ducts in the basement by means of a disc fan, operated by steam power, and passes to points where indirect radiators are located; thence through the radiating surface to classrooms.

The latter building is equipped with modern heating and ventilating apparatus, which has been installed in every public school building in the city of Chicago since 1894, and consists of sections of vertical radiators located in the basement and erected in such a manner that the air is drawn from the outside by means of a fan or blower, which is operated by an engine. The air is forced through the radiating surface to a warm air distributing chamber; thence through individual ducts to each classroom. At the central point of distribution air at two different temperatures is manipulated automatically by the combined influences of a thermostat and damper, the former located in the classroom and the latter in the duct leading thereto. The maximum temperature in top chamber is 160° Fahr. The minimum temperature in lower chamber is 68° Fahr.

The standard temperature required by the Board of Education is between 65° and 70° Fahr., and when the temperature of a room reaches 70° the thermostat automatically changes the position of the damper in the duct in the chamber in connection with the classroom to an intermediate position, so that a sufficient amount of air at the maximum and minimum temperature is admitted through the duct to maintain the required temperature in classroom.

The Board of Education has not installed a steam heating plant in a modern building for the past twenty years without provision being made to move the air for ventilating purposes by mechanical means; hence it would be impossible to submit satisfactory figures comparing the cost of installation of the old style heating and ventilating apparatus prior to the period mentioned. The cost of fuel for heating buildings provided with the old apparatus without mechanical ventilation, as compared with buildings of the same number of rooms equipped with modern heating and ventilating plants, is as follows:

FUEL EXPENSE IN BUILDINGS OF SAME SIZE.

School.	Date.	Fuel cost.	System.
Rogers	1880	$470.00	OLD.
Stanley	1881	486.00	OLD.
Kosciusko	1903	455.00	NEW.
Headley	1903	514.00	NEW.

The system installed in the two former buildings is the gravity method of air movement, there being no mechanical means employed.

As a comparison of the cost of warming large school buildings, provided with direct and indirect systems and mechanical ventilation, compared with the modern apparatus, minus direct radiation, Mr. Waters finds that the average amount of fuel consumed for the total cubic feet of space heated, is as folows:

CONSUMPTION OF COAL PER CUBIC FOOT OF SPACE WARMED.

Building.	Space heated.	Coal per yr.	Coal per cu. ft.
Buildings with Old Apparatus.			
Bancroft	448,282 cu. ft.	553,262 lb.	1.23 lb.
John Crerar....	448,282	556,797	1.24
Hammond	457,532	393,025	.86
Knickerbocker .	448,282	489,557	1.09
Horace Mann .	457,532	526,585	1.15
Average	....	....	1.11
Buildings with New Apparatus.			
P. D. Armour.	424,39[illegible]	256,444 lb.	.604
John C. Coonley	592,697	353,825	.596
Fernwood	236,722	184,600	.779
Arthur A. Libby	587,692	432,897	.736
W. K. Sullivan.	540,901	364,415	.673
Average	....	....	.677

The average classroom in the Chicago public schools is 26.6 ft. wide, 33 ft. long, 13 ft. 3 in. high, and contains 11,589 cu. ft. Using this classroom as a basis, the requirements for buildings first above named, per classroom equivalent, is 12,861 lb. coal, or 6.43 tons; which at $2.60 per ton (average based on the present contract prices for bituminous coal) amounts to $16,718. Similar classrooms in the last named buildings require 7,844 lb. of coal, or 3.92 tons per room, which at $2.60 per ton, amounts to $10,192. The figures do not represent the actual coal consumption per room, but include the heating of all the air necessary for corridors, basement rooms, etc. For the purpose of comparing the efficiency and economy of the apparatus under consideration, the classroom equivalent was used.

The average wages of a steam fitter and helper in 1889 were $4.50 per day, 9 hours' work, or per hour, 50 cents. The average wages of a steam fitter and helper, from 1900 to date, for 8 hours' work were $7.00 per day. The average increase in wages paid steam fitters and helpers has been 75 per cent. In this connection it must be borne in mind that in 1889 the contractors were allowed to work three helpers with one steam fitter, but at the present time this is not permissible, one helper only being allowed to work with one steam fitter; consequently the average increase of labor costs would amount to 90 per cent.

It is a different matter to arrive at anything like a just comparison, so far as the cost of materials is concerned, but it is safe to assume that there is very little change, when the cost of various fixtures is taken into consideration.

It will be readily seen by any person conversant with the construction of steam heating apparatus, that the cost of repairs increases materially with the age of the system of direct radiation. Large sums of money have been paid by the Board of Education for repairs to heating apparatus of this character, owing to the neglect or incompetency on the part of engineers allowing pipes to freeze. The modern heating apparatus, under ordinary conditions should last a life-time with very slight repairs, as there is no possibility of pipes being damaged through the action of frost, the entire plant being located in the basement adjacent to the boiler room.

It requires between three and four hours properly to heat a school building provided with the old system of steam heating apparatus, when the temperature is 15° below zero. It is possible to heat our largest school buildings provided with the modern system, with the outside temperature 20° below zero, in one hour after the engine is placed in operation. The new apparatus is so designed and the specifications require that each pupil in a school building shall be furnished with 30 cu. ft. of air per minute, or 1,800 cu. ft. of air per hour. This means a change of air in each classroom containing 54 sittings, seven times per hour.

Book Notes.

Several years ago a short article appeared in the "Journal of the Worcester Polytechnic Institute" describing the methods to be followed in keeping surveying instruments in adjustment. Prof. H. C. Ives, the author, had these notes printed for use in his classes, and the demand for them from engineers had led to their republication in a small board-bound pamphlet bearing the title "Adjustments of the Engineer's Transit and Level." The notes explain in concise and clear language the methods to be followed in such work. (New York, John Wiley & Sons, 25 cents.)

A little book that should prove welcome to a good many people is Mr. R. M. Starbuck's "Mechanical Drawing for Plumbers." In all first-class plumbing work it is desirable to keep a record of the piping and connections, and, as much of the detail of plumbing is generally left to the plumber, he will find it useful to acquire sufficient ability in mechanical drawing to prepare clear and neat diagrams of his work. Directions for doing this are given in this book, which is also interesting for the considerable number of good plumbing jobs illustrated. There are a few mistakes in some of the illustrations, but these are of no importance, and the book as a whole deserves praise as an attempt to raise the character of the business methods of this important trade. (New York, Plumbers' Trade Journal.)

A book that will be found useful in all offices where much steelwork for buildings is designed is Mr. G. D. Inskip's "Tables." About 15 years ago the author computed for his own work a table giving the squares of numbers expressed in feet, inches and eighths, which was published about six years ago. Two years ago he published a book on roof framing in which there was a table of logarithms of feet, inches and thirty-seconds. The reception accorded to the works has led him to compute the excellent tables given in the present volume. It gives the logarithms and squares of feet, inches and thirty-seconds up to 100 ft., the logarithmic secants for hips and valleys and common rafters from 0 to 18 in. advancing by thirty-seconds, natural and logarithmic functions of angles for every minute of the quadrant, logarithms of numbers arranged in the usual manner and also by sixty-fourths of an inch up to 12 in., and the decimal equivalents of fractions of a foot. Full explanations of the use of the tables and the methods of computing and checking them are given. The printing and binding are particularly well done. (New York, Myron C. Clark Publishing Co., flexible leather, 277 pp., $3.00.)

In the "Book Notes" printed in this journal on Feb. 17, there was a notice of Mr. Edward Godfrey's "Tables" which conveyed a wrong impression with regard to certain tables. In the preface the author gives a general credit to the Carnegie Steel Co. for what may be called standard data, and on this account the statement that such tables were republished without credit was incorrect. The resemblance between some of the tables and those in Osborn's "Handbook" is only in form, as stated in the following note to the author by Mr. Frank C. Osborn: "I notice, of course, a marked similarity in a number of the tables and sections, but at the same time, there is difference enough to show that they would have of necessity to be independently computed." Mr. Godfrey states that the typographical resemblance in the tables of decimals of a foot to those in "Cambria," to which the review referred, did not appear to him to call for credit, inasmuch as the identical type and arrangement was used also in an early edition of the Carnegie "Pocket Companion"; and that, with unimportant exceptions, the tables not original with him were from the Carnegie manual and duly acknowledged in the preface, as before stated. The fact that the book is a useful one, which was stated in the notice previously published, is shown by the purchase of a very large number of copies by the draftsmen employed by the American Bridge Co.

The latest addition to Oldenbourg's technical manuals is an admirable book of 225 pages, entitled "Ueber Wasserkraft- und Wasser-Versorgungsanlagen." The author, Mr. Ferdinand Schlotthauer, has aimed to produce a practical handbook, as distinct from a scientific treatise, but still a book which will be so explicit that mistakes in applying its rules and formulas will not be likely to occur. In order to accomplish this end numerous examples are worked out completely so that not only the principles, but also their practical applications, are explained. The author has also been successful in presenting his subject in a very concise manner, differing considerably from the ordinary rather diffuse German style. The book is in two parts, the first covering hydraulic power developments. It opens with a number of sections on the discharge of rivers and the methods of measuring it, which are followed by an explanation of the computations made to determine the size of canals and the dams, directions being given for each step followed in the design of such works. There is also an excellent section concerning a number of practical matters connected with dams, canals and turbine stations which are not affected by computations, but must be carefully considered in all hydraulic power designs. This discussion is followed by a number of sections on pipe lines, and an explanation of the method of determining the available daily discharge of a stream under different conditions. The second portion of the book, on water-works for small towns, opens with an explanation of the method of ascertaining the required amount of the supply and the different classes of works for obtaining it. The details of ground-water supplies are explained and then the supplies from surface sources are considered. There are simple rules for determining the general dimensions of pumping equipment, service reservoirs and water-towers, and a section on the design and management of syphons will be found particularly interesting. The same is also true of the description of hydraulic rams. The detailed explanation of the design of the network of street mains and the hydraulic conditions in it is very good; in fact, it deserves to be placed alongside the discussion of the same subject given a good many years ago before the New England Water-Works Association by Mr. John R. Freeman. Suggestions are also given for the design and installation of the accessories of street mains and services. A feature of the book which will specially commend it to engineers is the large number of tables, serving to reduce the actual arithmetical work of computation to a minimum. (Munich and Berlin, R. Oldenbourg; cloth, 225 pp., 7 marks.)

GARBAGE CREMATORIES IN AMERICA. By W. M. Venable. New York, John Wiley & Sons; cloth, 8vo, 200 pp., $2.00.

People who wish to understand the development and present condition of the methods of garbage disposal used in this country will find a great deal of useful information in this book. It is written by an engineer connected with a company which constructs crematories, but no indication of biased views on this account can be detected unless it is a prejudice against the reduction process of disposal that is not shown by most engineers who have studied its capabilities. The author makes some good points concerning the difference between the garbage disposal problem in this country and in Great Britain and gives a good deal of information concerning British incinerating works and the power plants often connected with them. He finds that in most of the small cities in the United States the crematory must be capable of burning either kitchen garbage, or miscellaneous refuse or both, and it is specially important to ascertain before the crematory is designed the quantities of each class. Whether it will pay to attempt to recover any materials in the refuse or to develop steam for power purposes depends on local conditions, chiefly on the quantities of materials to be handled, the cost of hauling, the market for the products, the price of power, and the ability to enforce a separate collection of garbage, refuse and ashes. For most American cities, the author believes that the separate collection of ashes and their use as filling on low land, and the separate collection of rubbish and garbage, and their burning together in crematories of moderate size near the centers of collection districts, form the most advantageous solution of the general problem.

In the opening chapter the general problem of disposing of waste materials is discussed from the point of view of American conditions; the picture of present conditions presented by the author is not flattering to our city officials, who have had to grope about in the dark considerably, owing in some measure to the absence of just such a book as this. In the second chapter there is an instructive summary of the quantities of the different waste materials and the systems of collecting them, the tabular data being derived mainly from Mr. Rudolph Hering's valuable paper on garbage disposal read before the International Engineering Congress at St. Louis. The third chapter considers the problem of burning refuse without offense, and in the succeeding chapter the various patented crematories for this purpose are described. By confining himself mainly to patent office papers for his information, the author has overlooked the fact that the first garbage furnace regularly used in the United States was constructed by the Quartermaster's Department of the U. S. Army, at Governor's Island, at the suggestion of The Engineering Record. It was so successful that it was adopted as the standard pattern for army posts and many of them were constructed, a number of them by regular crematory contractors who have listed them as their "works," although failing to indicate that the army designs were followed. The fifth chapter, on cost of operating a crematory, gives useful information of a general nature.

The leading crematory types and the extent of their use are described in a very interesting chapter, which shows that the subject has attracted the attention of a considerable number of inventors, of whom very few were able to produce designs worth considering. The blind folly with which the builders of a furnace successful under one set of conditions guaranteed equal results under totally different conditions is one of the most interesting as well as deplorable incidents in American refuse disposal history, explaining the general lack of confidence formerly felt by city officials in propositions from furnace builders. For information on the generation of steam by burning refuse, the author very properly turns to British practice, although notes on the Boston and New York furnaces are given. The methods and materials of construction used in the better class of incinerators are explained, there is a chapter on crematory chimneys, and in the closing chapter the author sums up his suggestions and opinions. While the book discusses only a part of the general subject of garbage and refuse collection and disposal, it is a useful guide so far as it goes, and the few points in which it is open to criticism are, except in the case of the value of the reduction process, of such minor nature that it is not worth while mentioning them.

Letters to the Editor.

THE COST OF ENGINEERING WORKS.

SIR: The letter from Mr. Campbell published in The Engineering Record last week concerning the cost of some of the reservoir works of the Reclamation Survey, taken in connection with the short article in your journal of May 12, on the same subject, pretty well covers one of those subjects which cause consulting engineers considerable trouble. I have been called on a number of times by public boards to design works, only to find on talking over the matter with the officers that they had secured information concerning similar works elsewhere and expected to duplicate in their own city the lowest expense for the same class of works in other places. The idea they had seemed to be that a water-works plant or a sewerage system was on just the same plane as flour or coal. It happens in perhaps half the cases with which I am connected that the first part of my duties is to show the board in charge of the projected works that the nature and consequently the cost of the undertakings they have in charge depend on local conditions. A considerable experience has fortunately given me an opportunity of collecting figures of cost of similar work by responsible contractors working on a moderate margin of profit in different portions of this district. Such figures and an explanation of the reason for their very wide variation are generally sufficient to convince the board that the one thing which it must not rely upon, except in a very broad way, is a compilation of cost data of similar work elsewhere.

I venture to make this statement because I have several times found that the figures given in the Current News Supplement of your own paper were misleading some of the boards which consulted me. These figures are of very little value except as indications of the unit prices which rule for certain classes of work on the particular undertakings referred to. Engineers and contractors know perfectly well that on small reservoirs, sewers, pumping plants and the like the expense depends in a considerable degree on the cost of getting materials to the site. In other cases the condition of the labor market is the most important factor in determining the cost. In other cases peculiarities of design or special requirements concerning the methods of conducting the construction affect the cost materially. None of these factors is indicated in the general statements usually made public concerning the expense of engineering works and accordingly the figures will be sure to mislead people without technical information.

Another aspect of the same subject that has occasionally caused some of my clients to think that another engineer ought to be engaged is the comparison of the cost of conducting the same kind of works in different places. Not long ago I prepared plans for a small water-works system. The town was one which had very limited resources and accordingly the plans had to be drawn with constant attention to balancing first cost and the charges for operation and maintenance in such a way that the most economical plant during a short period of years was furnished. When the plans and specifications were prepared, I sent with them a detailed statement of the probable operating and maintenance charges, and was not wholly surprised to receive a speedy call from the water committee to visit the town. On meeting the committee I found that it had obtained from neighboring places statements of the charges for the same services, which in every case were below those in my estimate. Accordingly we held a kindergarten session in the elements of municipal bookkeeping. In few cases had any allowance been made for depreciation and one or two places had not included any interest charges. Some of the plants were gravity supplies from nearby sources, so that the cost of the works was low and their operation of an elementary nature, and in few places were the pipes of satisfactory size. In the case of pumping plants, the methods of operation were so unlike as to be incapable of comparison in some respects. Nevertheless it was possible to show that the proposed plant would be less expensive than the majority of those of the same character with which comparison was made, provided the comparison was properly drawn.

Yours truly, M. AM. SOC. C. E.

Chicago, June 11.

VACATION PRACTICE.

SIR: It was very gratifying to read your editorial on Vacation Practice in the issue of June 2. It has been the writer's opinion for some time that it would be a step in the right direction if engineers generally could be persuaded to give the engineering students preference for vacation employment. He has seen many capable and deserving students of even the junior and senior years refused such positions as chainman or rodman; while these positions were filled by mere boys who happened to be related to some chief clerk. There are technical students whose usefulness on a field party is doubtful. But it is nevertheless true that an engineer, wanting loyal and willing assistants will do well to look through the ranks of the young men who are in college with a definite purpose, and who are eager for practical experience along with their technical training.

RECENT GRADUATE.

New York, June 5.